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DINOFLAGELLATES[1]

By
KAREN A. STEIDINGER AND JEAN WILLIAMS

ABSTRACT

During the Hourglass Cruises (a systematic sampling program in the eastern Gulf of Mexico), 232 dinoflagellate taxa were recorded from 504 live and 41 tow samples. These collections were taken over a 28 month period from six stations located on transects between St. Petersburg and Ft. Myers, Florida. The majority of species were photosynthetic, armored and of oceanic/neritic origin and were present throughout the year. Species diversity increased in a seaward direction, accompanied by a decrease in cell densities. Trends of seasonal and horizontal distribution are presented, and observed salinities, temperatures and counts are provided for individual taxa.

Recent advances in dinoflagellate studies and primary production are reviewed briefly to indicate their status. A description of free-living dinoflagellates is supplemented by a glossary, generic descriptions, generic and specific keys, and 45 photographic plates. The description of free-living dinoflagellates is amended to include the pseudocolonial characters of *Polykrikos*. Possible emendations for *Gymnodinium* and *Gyrodinium* are outlined because of problems arising in the separation of these genera by the extent of cingulum displacement. Homonymy in *Peridinium* is briefly discussed.

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Contribution No. 148

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Effective July 1, 1969, agencies of the State of Florida underwent legislative reorganization and the Florida Board of Conservation was renamed the Florida Department of Natural Resources. Similarly, the former Division of Salt Water Fisheries became the Division of Marine Resources.

Additional thanks are due J. T. Gaudsmith, J. C. Presley and especially L. M. Lyons who at various times worked directly on the project. All showed an outstanding interest in the success of the project and their technical assistance is sincerely appreciated.

In a paper of this size, various persons have aided through discussion over the years: Dr. H. Curl, Jr. (Oregon State University), Dr. C. J. Dawes, Dr. T. L. Hopkins (both, University of South Florida), Dr. W. B. Wilson (Texas A & M) and especially Mr. R. M. Ingle (Chief, Bureau of Marine Science and Technology, Florida Department of Natural Resources).

INTRODUCTION

"Red Tides" and associated catastrophic mortalities occur worldwide in freshwater and marine habitats. Their sporadic outbreaks stimulate public and governmental interest in research directed towards defining and delimiting the interdependent parameters contributing to such phenomena. Florida, as well as other Gulf coast states, periodically experiences Red Tides caused by toxic dinoflagellates such as *Gymnodinium breve* and *Gonyaulax monilata*. The Florida Department of Natural Resources, Marine Research Laboratory has, since 1955, studied and published on numerous aspects of Red Tide. Our data adds to the above works by presenting the occurence and distribution of dinoflagellates from Hourglass monitoring stations over the Continental Shelf, off Florida's west coast.

METHODS AND MATERIALS

A complete description of stations, sampling gear and hydrographic data were presented in Volume I, Part I of this series (Joyce and Williams, 1969). Six of the Hourglass stations (F, G, H, N, O and P) off the Tampa Bay – Ft. Myers area (Text Figure 1, Table 1) were sampled monthly from August 1965 through November 1967. In addition, two fisheries stations (E and M) were sampled

TABLE 1. LOCATION OF HOURGLASS PHYTOPLANKTON STATIONS

Station	Latitude*	Longitude*	Established Depth ft.	meters	Approximate Nautical Miles Offshore*
E	27°37'N	84°13'W	240	73.2	78-due W of Egmont Key
F	27°03'N	83°14'W	128	39.0	42-due W of Venice
G	26°44'N	82°41'W	78	23.8	22-due W of Gasparilla Island
H	26°36'N	82°16'W	22	6.7	03-due W of Captiva Pass
M	26°24'N	83°43'W	240	73.2	92-due W of Sanibel Island Light
N	27°03'N	83°14'W	128	39.0	42-due W of Venice
O	27°19'N	83°00'W	78	23.8	21-due W of Longboat Key
P	27°35'N	82°51'W	20	6.1	05-due W of Egmont Key

*U. S. Coast & Geodetic Chart 1003 dated June 1966

Text Figure 1. Hourglass cruise pattern and station locations.

for phytoplankton on an irregular basis. All Hourglass samples were collected by the crew of the R/V *Hernan Cortez*, a converted shrimp trawler operated by the Marine Research Laboratory.

Middepth and bottom samples were collected with a Van Dorn water sampler, while surface samples were obtained with a polyethylene bucket. A total of 504 live samples were collected.

These were kept in one quart (946 ml) glass jars and brought back to the Laboratory for analyses. These samples were then transferred to 750 ml Erlenmeyer flasks and beakers were inverted over them to lessen evaporation. The flasks were kept in a temperature controlled room (ca. 25 °C) and approximately 15 inches from overhead fluorescent lamps (cool, white, 40 watts) for at least four hours prior to analyses. The light source aided in concentrating the positively phototropic organisms at the surface of the sample. Initially, this concentrate (3 ml. subsample) was examined microscopically and the diversity of organisms recorded.

Often, when a dinoflagellate was present in low concentrations (<1000/liter), this initial examination revealed its presence. After checking the concentrate, the flask was inverted and gently agitated to disperse the organisms uniformly. A 6 ml subsample was then examined in 2 three-well spot plates. It was at this point that additional organisms were recorded and all dinoflagellates were counted. The counts per milliliter were then converted to numbers of cells per liter. Those organisms found in the concentrate, but not in the agitated sample were recorded as less than 100 cells/liter. When it was difficult to distinguish and count small individuals (e.g., *Gymnodinium* and *Gyrodinium*), indices of relative density were given: 1-10, 11-100, 101-1000, etc./ml. This completed the first phase of our procedure and was accomplished within 36 to 48 hours after sample collection.

After species density was numerically determined, the sample was filtered (Millipore, HA or RA). The residue and filter scrapings were kept in solution (<10 ml) and then examined microscopically. This additional observation inevitably revealed armored dinoflagellates not recorded previously because of their paucity and random distribution.

Fifteen minute, oblique plankton tows (175 μ mesh) were usually taken at each station. This material was fixed and preserved in 3-5% buffered seawater formalin. A 2 to 5 ml concentrate of plankton was accumulated by sedimentation. This dense subsample was divided and diluted to facilitate examination. Although 132 samples were collected throughout the Hourglass sampling, only 41 were analyzed. This data is considered supplementary to live samples.

A Zeiss phase-contrast assembly and Bausch and Lomb dissecting and Dyna-Zoom microscopes were used for light microscopy. Initial observations were made at 45X, while critical work was attempted at 800 -860X. Photomicrography incorporated the preceding equipment with either a Zeiss 35 mm camera attachment or a Polaroid MP-3 industrial camera.

Black and white photomicrographs and "species vials" were considered preferable as reference material since permanent slides provided immovable specimens, oriented in one view which were sometimes damaged by the numerous transfers necessary for preparation.

Observations on plate tabulation in armored species was facilitated by separating the plates mechanically rather than chemically as described by Martin (1929). This was achieved by applying pressure to the coverslip. Unarmored dinoflagellates under the confinement of a coverslip and dehydration will quickly round out and lyse, while armored forms retain their general outline to some degree or at least with the release of the protoplasm, plate structures are revealed. Most unarmored species do not have horns, spines, lists or sharp angles. The distinction between "armored" and "unarmored" is made in the glossary. For *Pyrocystis, Ornithocercus* and other large or fragile forms, a coverslip was edged with silicon stop-cock grease and carefully lowered over the water drop containing the specimen until the two surfaces met. Usually, the drop did not spread out and was deep enough not to crush the specimen. The specimen could then be easily positioned for photomicrography and later retrieved for our reference vials.

Biomass was calculated for several of the more common species using volume. Various formulae for geometrical volumes were used such as those for cones, spheres, and cylinders, and often a combination of these were needed to calculate the volume of such organisms as *Ceratium*.

HISTORICAL RESUMÉ

Fish kills in association with discolored water were reported as early as 1844 in the Gulf of Mexico, adjacent to Florida's west coast. Later reports of animal mortality in the late 1800's and early 1900's were attributed to a variety of causes including freshwater influx, drastic temperature changes and poisonous gases.

A serious fish kill in 1946-1947 caused considerable concern because of the extensive area affected and its long duration. Dead fishes were estimated to litter the beaches from Cape Romano to Boca Grande Pass at better than 100 pounds per linear foot of shoreline. The economic significance of such a catastrophe was emphasized by the drop in tourism and resultant financial stress to motel and hotel owners, residents, and the State of Florida. Those who chose to stay suffered the putrid odors of decay, routine fish burial and minor respiratory ailments – later attributed to airborne toxic particles of red tide organisms. The responsible organism was recognized as an unarmored dinoflagellate and described and named by C. C. Davis (1948) as *Gymnodinium breve*.

This particular Red Tide and the identification of the causative organism as a dinoflagellate initiated interest in the dinoflagellate populations of Gulf waters and adjacent areas. Such data is scarce prior to 1948. Since then Connell and Cross (1950), Davis (1950), Connell and Cross, King (1950), Howell (1953), Graham (1954), Lackey and Hynes (1955), Florida State University Report (1958), Curl (1959), Simmons and Thomas (1961), Dragovich (1963), Dragovich and Kelley (1964), Steidinger *et al.* (1966, 1967a, b), Lackey (1967), Balech (1967b, c), and Wood (1968) have listed species diversity and distribution in various Gulf and estuarine waters. The most comprehensive recordings were supplied by Balech (1967c) and Steidinger *et al.* (1967b). Up to 1967, less than 100 taxa had been reported. Recent work has increased this number to over 400 species, varieties and forms. The large species diversity representing a minimum and the potential diversity, considering possible influx from the Caribbean, indicate a great wealth of dinoflagellates in the Gulf of Mexico and contiguous waters.

DESCRIPTION OF FREE-LIVING DINOFLAGELLATES

Unicellular, single, catenate (with or without attachment pores) or pseudocolonial. With or without pigmentation (autotrophic to saprophytic and phagotrophic). Less than 2 mm in length, generally less than 200 μ. Dominant active stage usually motile by means of two flagella, typically one transverse and one longitudinal (Dinokontae/Diniferina). *Polykrikos* (pseudocolonial) with up to 32 flagella per individual. Remaining subclass (Desmokontae/Adinina) with two apically inserted flagella. Cells apparently with cellulosic pellicle and/or valves or plates. Plates usually arranged in specific series.

Cells generally uninucleate, nucleus typically fingerprint-like (moniliform threads of chromatin), large and discernible (*Polykrikos* can have 2-16 nuclei per cell). When present, chloroplasts green, yellow, brown or intermediate shades depending on pigment ratios (chlorophylls:

carotenoids). Large vacuoles and numerous oil globules sometimes present. Pusules (non-contractile vacuoles) thought to aid in phagocytosis. Other components resolved by light microscopy include: ocelli, eyespots (stigmata), nematocysts, trichocysts and internal silicious star-shaped structures (pentasters) or silicious support network. Highly ornamented forms occur with striations, ridges, horns, spines, lists and tentacles.

Other dinophycean types include palmelloid, coccoid and filamentous forms as well as sac-like parasitic species. All dinoflagellates have in their development a motile stage that is characteristic of the class.

To augment the description, new data on encystment-excystment should be included because life cycle stages with an entirely different morphology have been recognized. Fossil dinoflagellates, hystrichospheres and some acritarchs have recently been recognized as fossil dinoflagellate cysts (spores). This mode of encystment-excystment is clearly an important alternative in the development and maintainence of the species when unfavorable environmental conditions exist, e. g., overcrowing and insufficient nutrients. Viable cysts and hystrichospheres (resembling fossil taxa) have been induced to excyst, producing forms of extant species of several armored genera (*Gonyaulax, Pyrodinium, Protoceratium, Peridinium, Diplopsalis* and a few others). Furthermore, some modern species are heterosporous. Spores or cysts have remained dormant in culture for nine months (*Gonyaulax digitalis*). Dinoflagellate cysts have been recorded from sediments all over the world and sometimes from plankton samples.

Characters considered stable and used in identification of cyst material include: position and shape of archeopyle (excystment opening), reflected tabulation, when present, and shape and size. Reflected tabulation is the plate tabulation (precingulars, postcingulars, apicals, antapicals and intercalaries) derived from ornate spines, septa and other ornamentation produced by respective plates. Archeopyles can be precingular, intercalary or apical openings.

The problem that has arisen from these findings is taxonomic. Until now a double standard existed, nomenclature for fossil forms and nomenclature for living forms. Those researchers actively involved (Dr. Wall, Woods Hole Oceanographic Institute and Dr. Evitt, Stanford University) suggest the adoption of a single nomenclature but hesitate to pursue this task until further experimentation is completed. In addition, Wall and Dale (1968c) suggest that descriptions of dinoflagellate taxa should include a description of the resting stage. There are of course, fossil records with no known corresponding living form.

REVIEW OF RECENT ADVANCES

Dinoflagellate systematics have been hampered by a variety of problems. Descriptions are often incomplete, poorly illustrated, based on insufficient or distorted specimens and contain little or no data on life cycles or polymorphism. In addition, the literature is widely dispersed, in many languages, and many authors have stressed different criteria.

Many of the older works, though at times inadequate or incorrect are still needed and used today as basic references for original descriptions. Some illustrations (Stein, 1883) are so detailed that one wonders how they were achieved in that era.

Since the 1940's, many critical works have been attempted at all levels including systematics, ecology, physiology, cytology and technology. The most recent advances include: 1) taxonomic alteration of certain genera and re-evaluation at the specific level, 2) regional monographic treatment of major genera, 3) new or clarifying cytological observations (usually through electron microscopy), 4) toxin properties and formulae, 5) new technology in toxicity and bioluminescent studies,

6) life cycle work through the use of artificial cultivation refinements, 7) nuclear observations, 8) observations on endogenous rhythms, 9) zooxanthellae studies, 10) newly proposed or revised terminology, 11) re-evaluation of standing crop and primary productivity research, and 12) studies on hystrichospheres.

Abé (1967a) incorporated the genera *Exuviaella* and *Prorocentrum* under the latter name, a consolidation needed for many years. Abé (1967b) also suggested, as did Balech (1967b), the consolidation of *Phalacroma* and *Dinophysis* under the latter name, a move perhaps less desirable than *Exuviaella* and *Prorocentrum.*

There have always been exceptions and intergradations between genera, between species and between varieties, but a decision has to be made whether to combine these genera or whether to recognize and specify the gradients. For example, in *Gymnodinium* and *Gyrodinium*, the distinguishing character is cingulum displacement, yet characters clearly associated with *Gymnodinium* are overweighed when cingulum displacement is greater than 1/5 the body length. A separate section, "Taxonomic Problems," discusses this topic in more detail.

Electron microscopy has revealed internal and external structures not previously observed or suspected for the Dinophyceae/Dinoflagellida, e.g., pore structure (Dodge, 1965b), chloroplast and pyrenoid structure (Dodge, 1968; Davis, 1969), pusule structure (Dodge and Crawford, 1969), trichocyst ontogeny (Dragesco and Hollande, 1965; Bouck and Sweeney, 1966; Davis, 1969), intricate thecal and subthecal structure (or pellicular substructure) (Dodge, 1967; Mornin and Francis, 1967; Dodge and Crawford, 1968, 1970; Taylor, 1968; Davis, 1969), complex ocelli structure (Greyet, 1962; Francis, 1967; Dodge, 1969), unusual eyespot ultrastructure (Dodge and Crawford, 1969), and what Dodge (1965a) proposed as a mesokaryotic nucleus. Ultrastructure studies on various species have shown several different types of nuclei with distinctive chromosomal material (some may be artifacts of fixation), but all seem to lack a spindle and chromosomal centromeres, unless Dodge's central body (1963) and Chunosoff and Hirshfield's (1967) central band are considered diffuse centromeres. According to Kubai and Ris (1969) the divided chromosomes move to daughter cells through cytoplasmic channels thus compensating for the lack of a spindle apparatus. Their data further point out that dinoflagellate nuclear division is in between that characteristic of prokaryotic and eukaryotic cells. Chromosome counts are of little value considering they can constitute a range in a single species (Dodge, 1963d). However, gross chromosomal and nuclear morphology may be distinctive at the generic level (Dodge, 1963d) providing there are no artifacts of fixation.

Other organelles and structures resolved by electron microscopy are: endoplasmic reticulum, golgi (dictyosomes), lysosomes, various mitochondrial structures, vacuoles, flagella and scintillons associated with bioluminescence. Ultrastructure is a new and attractive field, drawing many researchers and new data is published monthly.

Abé and Balech were among the first to stress sulcal plate tabulations for generic differentiation. Since then several new genera and species have been transferred or named on this basis. True, sulcal plate distinction is necessary for a complete description, but is it so specific and without variation that it warrants a position as *the* separating character? For example, the sulcus (and/or the ventral area) is probably where ingestion takes place, e.g., with pseudopodia or extended pusule, through a pore or dispensable plate. This suggests that it might be an area subject to alteration or modification on an individual basis rather than at the specific level. However, Dr. Balech (personal communication) has just completed a study on the consistency of sulcal plate morphology and tabulation and considers this dynamic region critical in taxonomic analyses. The answer to this problem awaits clarification, particularly in recognition of Wall and Dale's (1968c) speculation that these plate analyses may not be as critical as resting spore descriptions.

Several authors have redefined portions of Kofoid's (1909) original plate nomenclature to

accommodate the "exceptions" that have arisen since the early 1900's. These proposals are based primarily on homologous series, for example, in *Gonyaulax monilata* and *Pyrodinium bahamense* there is a ventral plate displaced from the apex and touching the sulcus that could be called the 1st apical or a precingular plate, but it is positioned as the 1st apical plate of related armored dinoflagellates. Recently, Wall and Dale (1969) disclosed a 6th postcingular plate for *Pyrodinium bahamense*, thus giving it a plate formula equivalent to *Gonyaulax*. Is *Pyrodinium* a *Gonyaulax*? Wall and Dale have kept it a separate genus based on a large apical platelet, apical spines and strong sulcal crests. In addition they determined that its "hystrichosphaerid" resting stage was unlike any known *Gonyaulax*.

New equipment and preparatory techniques such as the scanning electron microscope will no doubt prove exceptional for marine phytoplankton studies, particularly those that relate to thecal or skeletal characters and associated systematics. One obstacle concerning electron microscopy, both transmitted and reflected, is the initial cost and equipment maintainance. The second obstacle is preparation procedures, the time involved and their effect on the organism at the subcellular level. Live examination with megavolt electron microscopes (10^5 X magnification) has been accomplished. Specimens have been exposed to electrons using an image intensifier for relatively long periods of time (a few minutes) and survived. The implications of this advancement are obvious and its impact on our knowledge of phytoplankton cytology and physiology will be revolutionary.

Recent life history investigations of protista have already yielded significant new data. Zooxanthellae of hermatypic corals, sea anemones, radiolaria and other invertebrates have been shown to be cystic endozoic stages of dinoflagellates (McLaughlin and Zahl, 1966; Taylor, 1968). Endogenous rhythms such as diurnal, tidal or lunar periodicity for photosynthesis, bioluminescence and cell division have been demonstrated (Sweeney and Hastings, 1962; Sweeney, 1964). Photosynthetic diatoms and dinoflagellates have been collected from the aphotic zone and cultured (Wood, 1969). Pleomorphism, in a clonal culture of *Gymnodinium mirable* showed various growth phases with characters of five other species of the genera *Gymnodinium* and *Gyrodinium* (Kimball and Wood, 1965). The possible existence of male and female gametes has been shown for *Ceratium tripos* (Von Stosch, 1964).

Wall and Dale (1967, 1968a; 1969) have shown that some "fossil" forms called hystrichospheres are actually present day cysts of *Gonyaulax digitalis, G. spinifera* and *Pyrodinium bahamense*, among others, and have stimulated these "fossils" to excyst.

Many *Gonyaulax* and some *Gymnodinium* and *Amphidinium* species have been shown to produce endo and exotoxins. A review by Loeblich III (1966) discusses advances in toxicity studies. Recent toxin studies indicate that all toxins are not alike, structurally or pharmacologically. *Gonyaulax catenella* has a formula of $C_{10}H_{17}O_4N_7.2HCl$, a toxin causing paralytic shellfish poisoning while *Gymnodinium breve* has toxin(s) (Substance $2-C_{90}H_{162}O_{17}P$, Martin and Chatterjee, 1969) with ciguatra-like effects. Various researchers are concentrating on structural, pharmacological and comparative properties of these toxins.

REVIEW OF PHYTOPLANKTON PRODUCTION

Primary productivity studies and associated analyses such as chlorophyll content, respiration and photosynthetic activity by light-dark bottle and C^{14} assimilation methods have come under recent criticism. Do chlorophyll results give accurate data for the interpretation of standing crop? Are primary productivity studies actually measuring productivity or an altered aspect of standing crop?

All data depends on collection techniques. Is the sample representative of the area, is it contaminated or damaged? Plankton patchiness as described by Wiebe and Holland (1968) further

complicates this problem. Many new collection methods are being developed and tested to provide more accurate data. One method involves pumping of water samples from various depths but some cells are distorted or destroyed in the process, thus reducing its accuracy. A better method is the entrapment of water with a minimum of disturbance. A non-metallic or teflon coated (non-toxic) container such as a Van Dorn, can be triggered to sample specific strata. This method also lends itself to photosynthesis/respiration studies, if predators are removed to avoid grazing pressure which would affect the results. Strickland (1965) recommended surface samples taken at a sub-surface depth to avoid the air-surface interface.

Methods for concentration of phytoplankton organisms without cell disruption are also under intensive study. Most of these involve mild centrifugation and low pressure filtration, but there is some loss and distortion with even the most gentle. Dodson and Thomas (1964) and Pomeroy and Johannes' (1968) gentle concentration methods have little loss, but are time consuming and inefficient when large volumes are involved. Sanford, Sands and Goldman (1969), working with freshwater organisms, reported on a "settle-freeze" method for quantitative studies with apparently little distortion to fragile forms. This procedure involved (in a step-wise series): fixation, sedimentation, freezing, thawing, dehydration, and mounting for permanent reference.

Measuring plankton biomass volumetrically can be accomplished by converting length, width and depth measurements to volumetric values or by determining displacement volumes. Problems arising with volume are centered around the question, does total volume represent the active protoplasm (Paasche, 1960; Strathmann, 1967)? Actual cell counts are also used extensiveiy. It is recognized that counts or organisms may not be indicative of usable materials that are passed from one trophic level to another, but identification and cell counts are the most valuable and reliable means of assessing phytoplankton populations.

The Coulter Counter can be used to determine densities in unialgal populations, plotting growth curves or even to determine grazing pressures (Sheldon and Parsons, 1967). Mulligan and Kingsburg (1968) have suggested this counter as a means of estimating natural population biomass volumetrically. However, the problems are insurmountable, e.g., how to distinguish phytoplankton from zooplankton, species from species, living from dead, photosynthetic from non-photosynthetic as well as chain forming species and particulate matter which give false readings.

Gaarder and Gran in the late 1920's devised a method to measure primary productivity by utilizing photosynthesis/respiration activity. The problem with this method is not theory, but technique. The confinement of the protista in a glass bottle allows time for populations to be altered, thus altering the chemistry of the entrapped seawater. In addition, Martin (1968) and Wells and Warinner (1968) have mentioned oxygen losses caused by temperature and pressure changes and biochemical processes. Furthermore, some research indicates that bacteria respire more in the dark bottle than the light bottle (decomposition) and the surface of the container provides a substrate for adherence of flagellates, bacteria and other microorganisms, thus affecting metabolism, respiration, and consequently, the oxygen content (Verduin, 1964). Additional sources of error are: 1) inhibition of photosynthesis in the light bottles by shading, grazing, exocrines or interaction of all three, and 2) excessive decomposition by bacteria. Williams and Askew (1968) measured heterotrophic respiration in seawater by adding a labeled substrate (glucose) and measuring the resultant radioactive carbon dioxide. Such methods could possibly be used as a correction factor for heterotrophic respiration in light/dark bottle experiments.

Methods involved here are dependent on the measurement of oxygen, either in situ or in the laboratory. Therefore, the first concern should be an accurate method for free oxygen determination. Considering the low range, 0-10 ml/liter, the method must be sensitive. Various modifications of the Winkler titration are used today; in addition, oxygen electrodes (polarography) are finding their place among field gear. Patten (1964), Martin (1968), and Murray, Riley and Wilson (1968)

discussed current procedures or corrections. One method (Broenkow and Cline, 1969) is recommended for low oxygen determinations because of its sensitivity (μg atoms/liter) and efficiency in eliminating atmospheric contamination.

Nielsen with his introduction of the ^{14}C method has perhaps created more problems than have been solved. The purpose of such a method is to introduce labeled carbon to the sample and allow the auto and auxotrophic components to "fix" the radioactive carbon into its cytoplasm by the process of photosynthesis. The sample is preserved and the organisms retrieved on a filter to measure the amount of radioactivity. This procedure requires light/dark bottle incubation and is reported to measure rates of 0.1 mg $C/m^3/hr$ (Strickland, 1965).

The ^{14}C method has several inaccuracies all of which serve to lower the actual readings. For example, Geiger counters, used to measure radioactivity, will absorb some radioactivity. Liquid scintillation has been recommended to lessen this error (Wolfe and Schelske, 1967; Lind and Campbell, 1969). Lysis of cells releases radioactivity into the water which is not analyzed. Selective excretion of ^{14}C (Barnett and Hirota, 1967) would also enhance this error. Since the rate of ^{14}C uptake is a function of light intensity (Nielsen, 1963), it is understandable that carbon fixation shows diurnal fluctuations (Newhouse, Doty and Tsuda, 1967). In addition, ^{14}C assimilation is slower than ^{12}C (Nielsen, 1963). Various factors inhibit photosynthesis, e.g., ultraviolet light, thus reducing ^{14}C uptake (Nielsen, 1963). To compound the above deficiencies in ^{14}C techniques, the standard problems with bottle incubation and confinement have not been overcome. For example, how representative is the sample and how much can this artificial situation be equated to natural conditions.

According to Nielsen (1963) the ^{14}C method is a measurement of the rate of potential photosynthesis. Unfortunately ^{14}C uptake is influenced by species-to-species variability and physiology of the cells at the time of the experiment, particularly nitrogen and phosphorous deficiencies. The latter is also influenced by light intensity, temperature, *p*H and pressure. Therefore, data would portray potential photosynthesis only if conditions were optimum, which in the methods used today are not attained.

Biomass of photosynthetic protists has been typically measured by chlorophyll content. It is understood that chlorophyll *a* is the "active" pigment in carbon fixation and conversion, while the other pigments somehow assist the process. Therefore, chlorophyll *a* has been the primary pigment assayed for, although there are optical methods for interpreting chlorophylls *b* and *c*. Carotenoids have been relatively avoided in analyses of biomass, even though they are often dominant pigments in diatoms and dinoflagellates. The questions concerning chlorophyll determinations are: 1) is chlorophyll *a* a true indication of biomass in the trophic sense, 2) is chlorophyll *a* a measurement of the primary available food source, 3) are the methods standardized for worldwide, geographic comparisons, and 4) are the methods used today accurate? The answer to the first three questions is "no", and to the fourth, "probably not". Harvey Pigment Units are no longer accepted, while UNESCO's (1966) colormetric and Lorenzen's (1966) fluorometric analyses are extensively used, but both have intrinsic problems (Yentsch, 1965; Holm-Hansen *et al.*, 1965; Strickland, 1968). For example, phaeophytin (a chlorophyll breakdown product) must be accounted for in chlorophyll determinations.

Further experimentation is needed to establish the best method. While most research is concentrating on methodology, the real problem is only now becoming apparent. Is chlorophyll, or any pigment, a good standard to use in the estimation of primary biomass? Depending on the species present, groups represented and growth conditions, chloroplasts vary in number, size and pigment content per cell. They do not occupy the total volume of the cell and are minimal in regard to total organic matter accessible to the consumer. In addition, the amount of chlorophyll *a* is influenced by

light intensity, temperature and nutrient availability (Eppley, 1969), thus influencing the interpretation of horizontal and vertical distribution. For these reasons, carbon: chlorophyll ratios are being pursued.

The old method of determining dry weight of plankton size fractions and determining the percentage of organic:inorganic composition of this dry weight is still a reliable estimate of production. Organic dry weight can easily be converted to carbon content. The carbon:chlorophyll ratio is therefore perhaps the best method available today for estimating standing stock and takes into consideration both heterotrophic and photosynthetic populations.

The use of labeled nitrogen in estimating potential production has been suggested (Dugdale and Goering, 1967) in preference to labeled carbon or phosphorous. The replenishment of nitrogen sources by rainfall, the assimilation of nitrogen compounds at night and general nitrogen metabolism help support this method as a better source of productivity determinations. Measurements of basic nutrients have also served as an indication of potential productivity of various geographic areas, thus indicating the availability of ions needed to support a phytoplankton community. The analysis of nitrates, silicates, and other important substances in marine waters have been facilitated by the Autoanalyzer, thus providing another method of estimating production other than by carbon fixation and photosynthesis. The latter is an extremely important point because then unicellular heterotrophs normally excluded from productivity measurements may be recognized. The first layer of production supporting so-called herbivores is not all auto- or auxotrophic.

Another method of estimating (and predicting) primary production involves biological extinction coefficients and chlorophyll values (Platt, 1969). However, the problems here involve the history of the water mass and whether chlorophyll is an accurate account of biomass.

Holm-Hansen (1969) stated, "Some estimate of the total living crop of organisms, both autotrophic and heterotrophic forms is often desired and analyses for total organic carbon or protein are not feasible because of organic detrital material". Holm-Hansen, Sutcliffe and Sharp (1968) suggested that measurements of DNA may be correlated with planktonic organic dry weight or carbon content even though the evidence thus far shows a range for such a ratio. Holm-Hansen (1969a) showed that the amount of DNA/cell is proportional to cell size, e.g., 1-3% of the cellular organic carbon. However, Holm-Hansen (1969b) upon further investigation pointed out that DNA was a component of the detrital fraction and should not be used for biomass determinations. The measurement of ATP has also been used as a reference for standing stock (Holm-Hansen and Booth, 1966; Daumas and Fiala, 1969; Holm-Hansen, 1969b).

The goal of primary productivity studies, standing stock values, and in general, the major part of plankton ecology today is to better understand trophic levels and their interrelationships. Prior to this, Lindeman's (1942) trophic scheme had wide acclaim and still has its applications today. However, distinct levels need further analyses before they can be characterized as "herbivore," "primary producer," "secondary consumer," and other rigid classifications. Percentage transfers between levels is still rated at 10-15% (energy), but further work should be attempted on this aspect.

Bacterial aggregates (Sheldon *et al.*, 1967), mucoid aggregates (Johannes, 1967) and other potential aggregates provide microhabitats for diverse populations and for the adsorption of soluble materials (Pomeroy and Johannes, 1968). Some aggregates occur seasonally, associated with phytoplankton, chlorophyll *a*, and decreases in temperature and salinity (Kane, 1967). Darnell (1967) and others reviewed the role of detritus in the ecosystem. This phase of plankton ecology is perhaps the most significant at the present time. The importance of aggregates, detritus and fecal pellets in marine environments is receiving much attention.

This review on primary productivity and standing stock measurements is too brief to be

considered critical but is presented to show the reader that plankton ecology today is a broad spectrum of endeavors with very basic problems.

The Hourglass cruise data is cell numbers with projected cell volumes for some significant species. This data is reliable for species occurrence, seasonality, and distribution. Even though this data is significant, many of today's phytoplankton studies are concentrating less on basic systematics and ecology, and more on the dynamics and potential of plankton communities. Classical planktonology has little to do with radioactive labeling, fluorometers, and ATP measurements. Rather, it is a taxonomic and geographic probe using nets, buckets and samplers. This method of investigation has its proven merits; however, new methodology should not be ignored.

GLOSSARY

(Text Figures 2 through 8)

ANTAPICALS (Armored forms only, exclusive of Dinophysiales). Those plates (designated by "'") on the posterior part of the hypotheca in direct contact with the antapex. If the antapex cannot be determined, antapicals are usually the large innermost posterior plates.

ANTERIOR INTERCALARIES (Armored forms only, exclusive of Dinophysiales). If present, those plates (designated by letter *a*) between apicals and precingulars . The series is not normally continuous (gross exceptions noted in some *Pyrophacus* ecoforms).

APICAL PLATELET (Armored forms only). Analogous to a closing platelet between 2 valves, also the relatively small apical plate surrounded by the plates of the apical series. Certain species with porous platelets, some of which allow protoplasmic continuity between 2 cells.

APICALS (Armored forms only, exclusive of Dinophysiales). Those anterior plates (designated by ') of the epitheca that are in direct contact with (or in close proximity to) the apex, which is usually in the form of an apical closing platelet.

ARMORED. Cells with cellulosic wall of varying thickness, composed of valves or plates (usually sculptured with surface markings). If plates present, usually arranged in the following series: apicals, anterior intercalaries, precingulars, cingulars, sulcals, postcingulars, posterior intercalaries and antapicals.

CATENATE. Chain-forming armored or unarmored species with or without protoplasmic continuity between cells. If armored, cells usually with anterior and posterior attachment pores (one in apical platelet, the other in posterior sulcal plate).

CINGULUM (Synonymous with "Girdle"). Transverse furrow circling body, often greatly indented. Contains transverse flagellum. Some armored genera lack cingular area divided into plates, e.g., *Prorocentrum* and *Podolampas*. In Podolampas and others, there is a cingular area that is homologous to that of *Peridinium.*

CIRCULAR CINGULUM. Cingulum not displaced, both proximal and distal ends at same level.

DESCENDING SPIRAL. Cingulum displacement (left-handed) where the distal end is below the proximal end (right side below left). In contrast to an ascending spiral where the distal end is above the proximal.

DISPLACED CINGULUM. One end of the cingulum is below the other. This measurement is expressed in cingulum widths (e.g., 2X, 3X).

EPICONE (Unarmored forms only). The area anterior to the transverse cingulum.

EPITHECA (Armored forms only). The area above the cingulum, usually composed of apical, anterior intercalary and precingular plate series.

EQUATORIAL. When the transverse cingulum is situated at the hypothetical equator (median) of the cell.

EYESPOT. Not to be confused with ocellus (lens and melanosome). Recently shown to be pigment body near flagellum base associated with membranous lamellar structure.

HEXA (Peridinium and like genera). Usually refers to the six-sided nature of the 2nd anterior intercalary.

HORNS (Armored forms only). Hollow or solid extensions or attenuations of the apical, postcingular and/or antapical plates.

LEFT (Dinokontae/Diniferina only). The left side of the organism. The concept of left or right can only be determined if a sulcus is present, this establishes the ventral surface.

LIST (Armored forms only). Membranous cellulosic extensions of the cell, primarily limited to the cingulum and sulcus. Sometimes supported by spines or ribs. Left sulcal list of the dinophysoid types sometimes extends posteriorly and dorsally becoming lobed or crested. When present in relation to the cingulum, situated anteriorly and posteriorly to one another.

META(Peridinium and like genera). Usually refers to the five-sided nature of the 1st apical plate.

NEMATOCYSTS. Cytoplasmic stinging or entrapping organelles somewhat torpedo shaped, generally situated near the cell periphery.

OCELLUS (Unarmored forms only). Advanced photoreceptor organelle in non-photosynthetic species composed of lens and pigment mass (melanosome).

ORTHO (*Peridinium* and like genera). Usually refers to the four-sided nature of the 1st apical plate.

OVERHANG. In some species, the proximal and distal ends of the displaced cingulum overlap. This area of overlap can be measured and reported as amount of overhang.

PARA (Peridinium and like genera). Usually refers to the six-sided nature of the 1st apical plate.

PELLICLE. Resilient retaining envelope (may be theca composed of many polygonal plates) located exterior to plasmalemma. Observed in both unarmored and armored species.

PENTA (Peridinium and like genera). Usually refers to the five-sided nature of the 2nd anterior intercalary.

POSTCINGULARS (Armored forms only, exclusive of Dinophysiales). Those plates (designated by "') on hypotheca in contact with cingulum plates or homologous cingular area.

POSTMEDIAN. Transverse cingulum below hypothetical midpoint of cell.

POSTERIOR INTERCALARIES (Armored forms only, exclusive of Dinophysiales). Those plates (designated by letter *p*) on the hypotheca intermittent between postcingulars and antapicals. Series not continuous (gross exceptions noted in some *Pyrophacus* ecoforms).

PRECINGULARS (Armored forms only, exclusive of Dinophysiales). Those plates (designated by ") on the epitheca in contact with cingular plates or homologous cingular area. The 1st apical plate must not be included in this series if it interrupts the precingular area.

PREMEDIAN. Tranverse cingulum situated above hypothetical midpoint of cell.

PROTISTA. Dinoflagellates have recently been classified under the Kingdom Protista in the Phylum Pyrrhophyta. Protists are unicellular or colonial-unicellular eukaryotic (some mesokaryotic, like dinoflagellates) organisms.

PSEUDOCOLONIAL. A term applied to the genus *Polykrikos*, often described as colonial. Indicates that a single cell has undergone incomplete cytokinesis. The old and new products enclosed by a common pellicle.

PUSULE. Non-contractile vacuole associated with flagellar pores. Pusula of heterotrophic forms may be active in phagocytosis, although osmoregulatory functions have been suggested.

QUADRA (*Peridinium* and like genera). Usually refers to the four-sided nature of the 2nd anterior intercalary.

RETICULATIONS (Armored forms only). Usually raised surface markings, generally linear, forming a crosshatched appearance on the theca, but not permanently continuous from plate to plate.

RIGHT (Dinokontae/Diniferina only). The right side of the organism (see Left).

SULCUS (Located on ventral side). A longitudinal, narrow to broad, furrow composed of several small plates in armored species, sometimes depressed. Houses a whiplash flagellum.

SURFACE MARKINGS. Reticulations, vermiculations, intercalary bands, striations, poroids, ribs, protuberances, and other thecal or pellicular properties.

SUTURE (Armored forms only). Area of contact between two adjacent plates, or valves, sometimes associated with intercalary bands of striations.

THECA. Cell wall of cellulosic nature. Collectively 2 valves or the epitheca, hypotheca, cingulum, sulcus, and cell extensions if present. Recent studies suggest that most dinoflagellates are thecate to some degree, but not necessarily composed of the standard plate series.

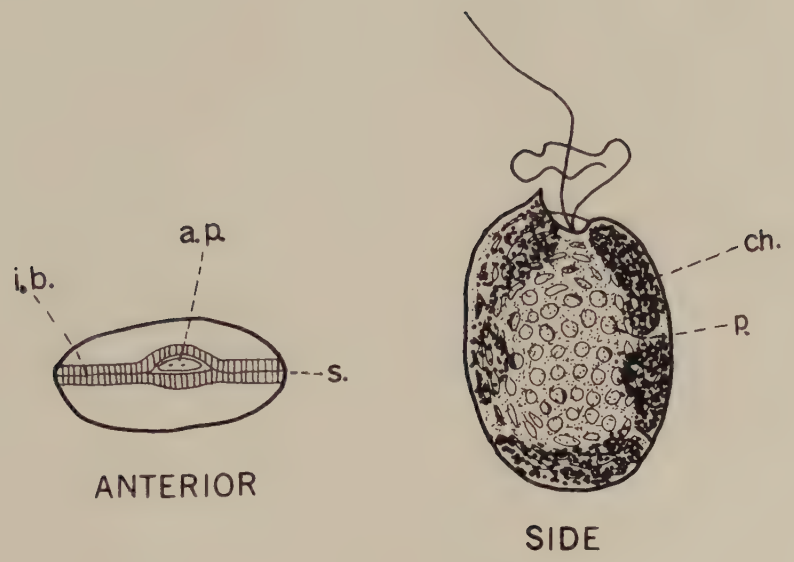
TOOTH (Prorocentrales only). An anterior, spine-like process, occasionally winged. A variable character depending on the environment.

UNARMORED. Lacking a cellulosic cell wall composed of valves or standard plate series. Consequently without spines, lists, and other thecal extensions. Protoplasm retained by cell membrane and/or pellicle.

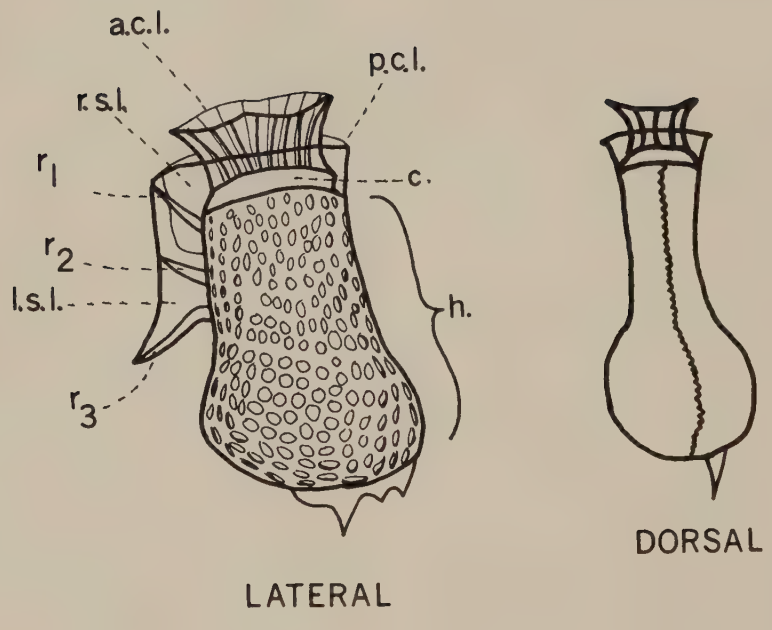
VALVES (Prorocentrales and Dinophysiales only). Two opposing halves, longitudinally arranged (Prorocentrales). In the Dinophysiales, what are sometimes referred to as valves are composed of several plates.

VENTRAL AREA (*Ceratium* only). Located in midbody area, composed of four plates, usually thin and transparent, sometimes sculptured. Sulcus to the left. Some authors consider the sulcus as part of the ventral area in such genera as *Gonyaulax* and *Peridinium*, while others consider the ventral area plates as part of the sulcus in *Ceratium.*

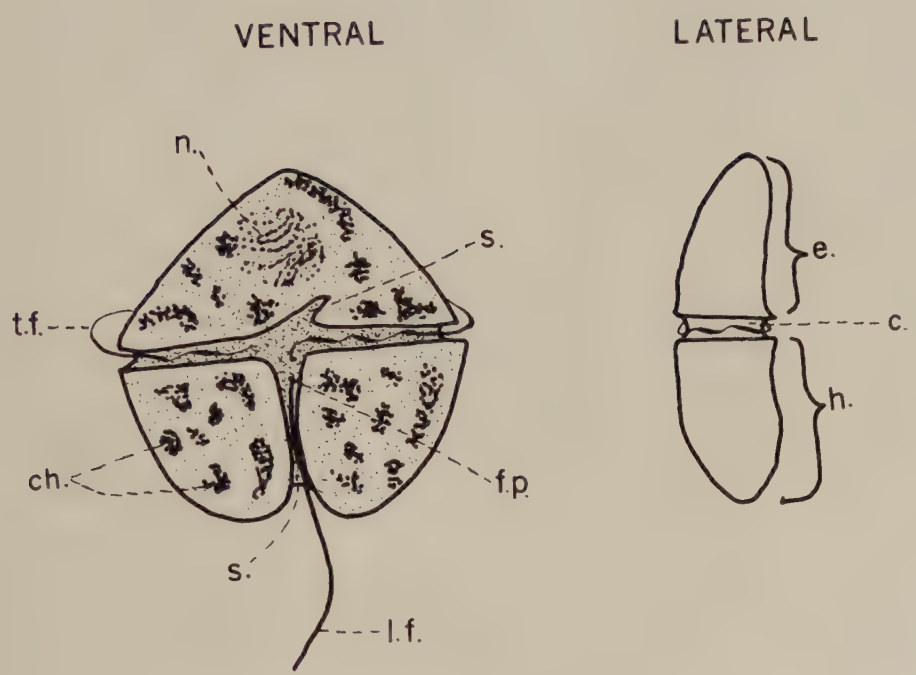
(TEXT FIGURES 2 THRU 8 INSERTED HERE)



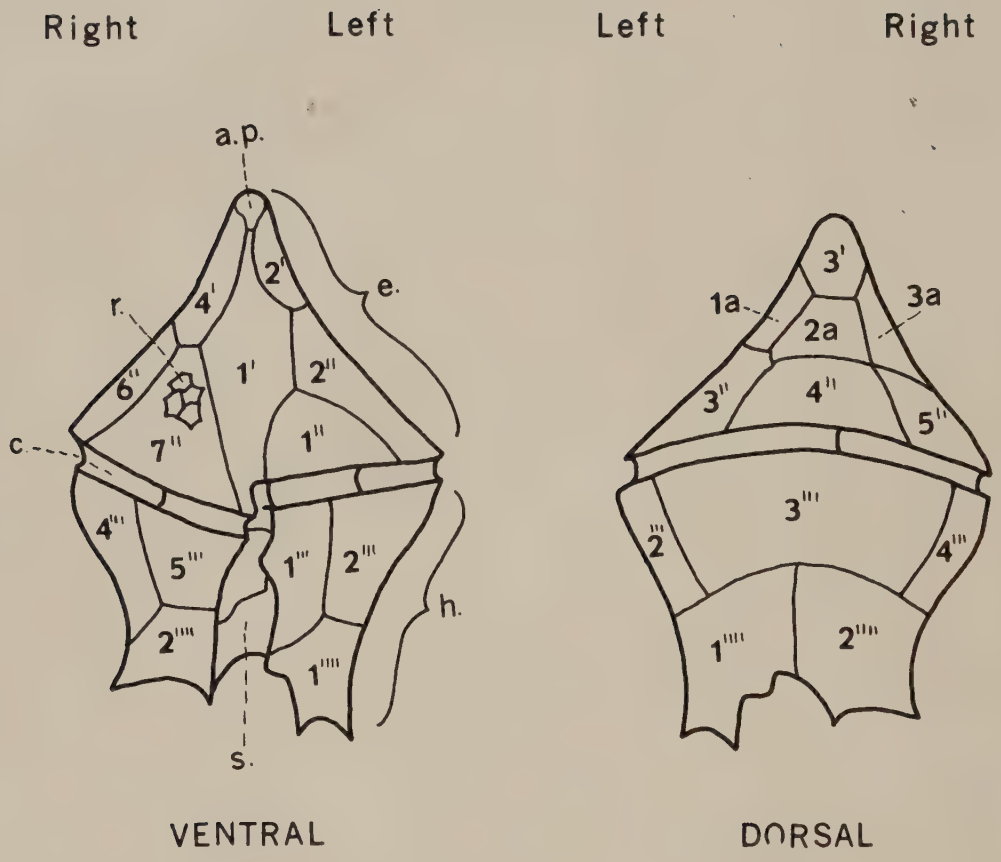
Text Figure 2. Anterior and side views of schematic *Prorocentrum*. Small apical platelet with flagellar pores located anteriorly between two valves. Area separating valves called megacytic zone, often characterized by wide intercalary bands transversing sagittal (fission) suture. Both flagella inserted anteriorly. Valves with poroids (pits).
a.p.– apical platelet, ch.– chloroplast, i.b.– intercalary band, p.– poroid, s.– suture.



Text Figure 3. Lateral and dorsal views of schematic *Dinophysis*. Even though the illustration seems to represent two opposing valves, these opposing sections are divided into plates: 5 epithecal, 4 cingular, 4 sulcal, and 4 hypothecal. Anterior cingular list, supported by spines, exceeds posterior cingular list. Left sulcal list supported by 3 ribs (R_1, R_2, R_3). Right, short, hyaline sulcal list can be seen through left sulcal list. Epitheca extremely short, hypotheca composing most of body.
a.c.l. – anterior cingular list, c. – cingulum, h. – hypotheca, l.s.l. – left sulcal list, p.c.l. – posterior cingular list, r_1 – rib 1, r_2 – rib 2, r_3 – rib 3, r.s.l. – right sulcal list.

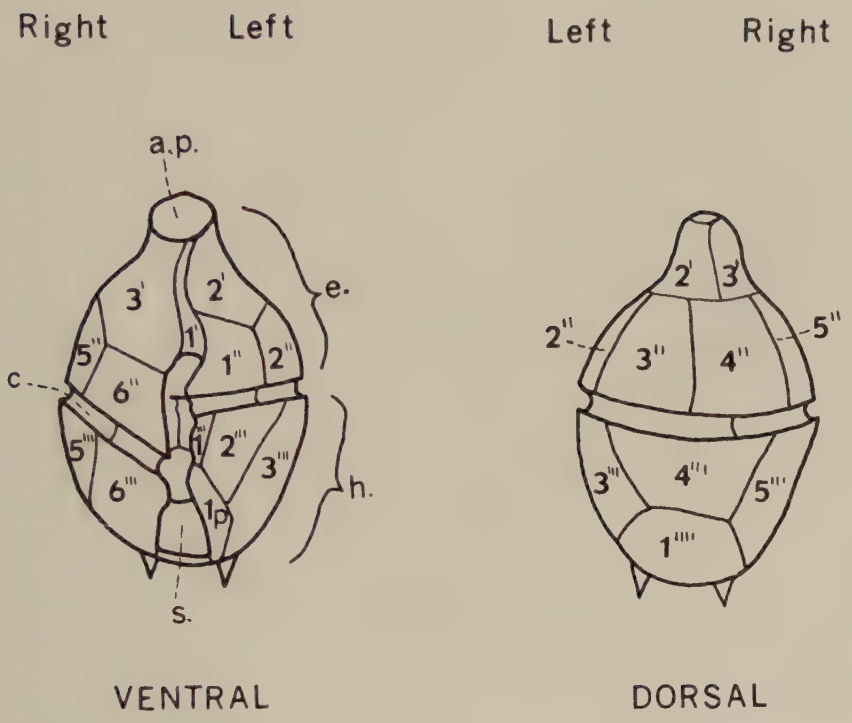


Text Figure 4. Ventral and lateral views of schematic *Gymnodinium*. Cingulum equatorial, not displaced. Sulcus, directed to the left, invades epicone for short distance.
ch. – chloroplast, c. – cingulum, e. – epicone, f.p. – flagellar pore, h. –hypocone, l.f. – longitudinal flagellum, n. – nucleus, s. – sulcus, t.f. – transverse flagellum.



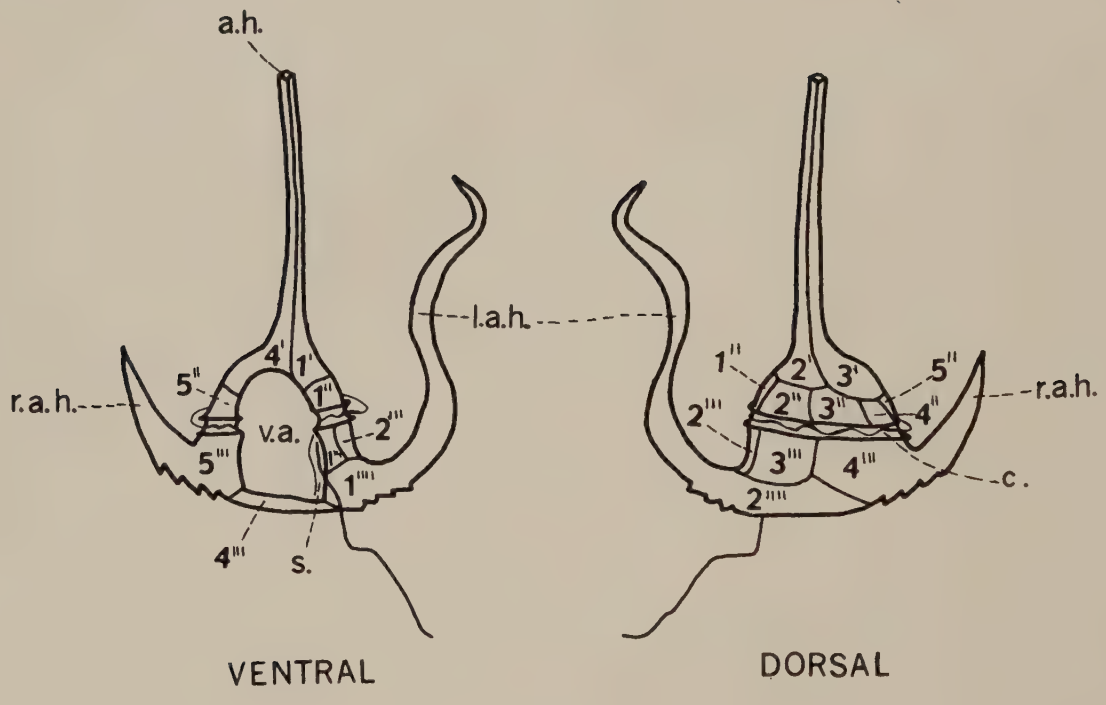
Text Figure 5. Ventral and dorsal views of schematic *Peridinium*. Cingulum descending spiral (about 1 width). Plate formula: 4', 3*a*, 7'', 5''', and 2''''. Sulcal area divided into several small plates (not illustrated).

a.p. – apical platelet, c. – cingulum, e. – epitheca, h. – hypotheca, r. – reticulations, s. – sulcus. ' – apical plates, *a* – anterior intercalary plates, '' – precingular plates, ''' – postcingular plates, '''' – antapical plates.



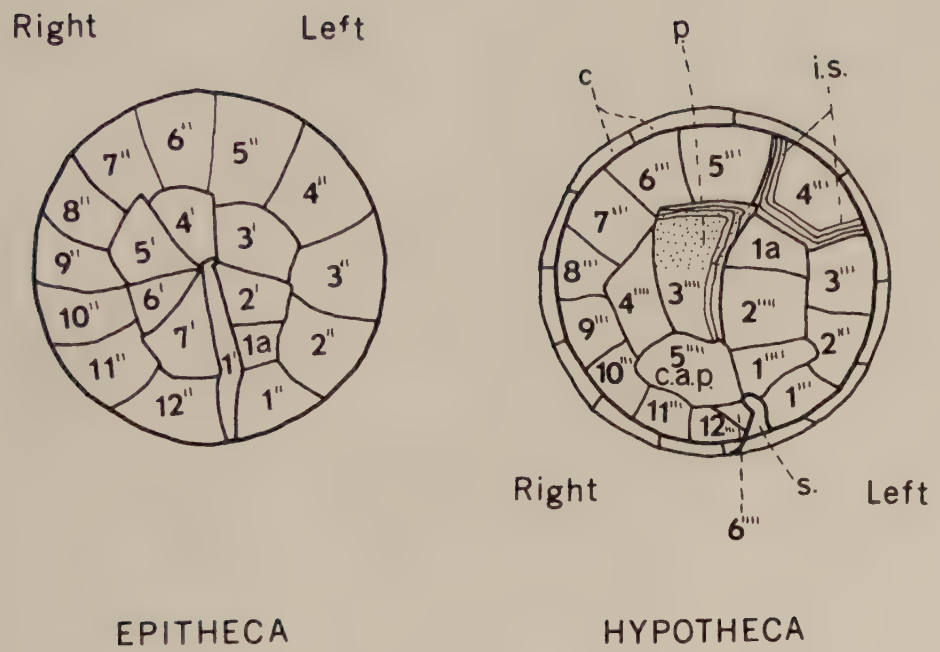
Text Figure 6. Ventral and dorsal views of schematic *Gonyaulax*. Note narrow 1st apical plate characteristic for most *Gonyaulax* and placement of posterior intercalary plate and antapical plate. Cingulum displacement acute without overhang. Plate formula: 3', 6'', 6''', 1*p*, and 1''''. Sulcus composed of several small plates. The apical platelet is commonly the exit for encysted protoplasm.

a.p. – apical platelet, c. – cingulum, e. – epitheca, h. – hypotheca, s. – sulcus. ' – apical plates, '' – precingular plates, ''' – postcingular plates, *p* – posterior intercalary plate, '''' – antapical plate.



Text Figure 7. Ventral and dorsal views of schematic *Ceratium*. Note distinction between ventral area and sulcus. Plate formula for all species in this genus: 4', 5'', 5''' and 2''''. Sulcus composed of several small plates, ventral area composed of 3 large and 1 small plate. First and 2nd antapical plates join to form left antapical horn, 4th and 5th postcingular plates join to form right antapical horn. Apical horn formed by all 4 apical plates.

a.h. – apical horn, c. – cingulum, l.a.h. – left antapical horn, r.a.h. – right antapical horn, s. – sulcus, v.a. – ventral area. ' – apical plates, '' – precingular plates, ''' – postcingular plates, '''' – antapical plates.



Text Figure 8. Epithecal and hypothecal views of schematic *Pyrophacus*. Plate formula: 7', 1*a*, 12'', 12''', 2*p*, and 6''''. Sulcus composed of several small plates. Fifth antapical plate serves as Coupling Antapical Plate. Those plates in contact with and including the c.a.p. are called antapicals. This modified nomenclature applies to the genus *Pyrophacus* only, but is not usable with aberrants.

c. – cingulum, c.a.p. – coupling antapical plate, i.s. – intercalary striae, p. – poroids, s. – sulcus, ' – apical plates, *a* – anterior intercalary plates, '' – precingular plates, '''' – postcingular plates, *p* – posterior intercalary plates, '''' – antapical plates.

GENERIC AND SPECIFIC KEYS

Characters used in these keys are based on light microscopy observations and may not be applicable for electron microscopy. Definition of terms used in this paper are presented in the Glossary, and some may disagree with similar terms of other workers.

The Generic Key is a revision of Steidinger, Davis and Williams (1967b) and includes additional genera (Gulf of Mexico) not reported in Hourglass material. Generic descriptions are diagnostic but brief. Species keys are limited to Hourglass material.

The genus *Kofoidinium* although found in local waters, was not represented in the generic key because of diverse life stages that can resemble *Amphidinium, Gymnodinium* and noctilucoid forms (Cachon and Cachon, 1967c). Another genus, *Glenodinium,* was also excluded because of variable plate tabulation and dubious assignment of its species.

GENERIC KEY

1a. Cells immobile in dominant stage, bladder shaped with large dinophycean nucleus, stranded protoplasm radially arranged . . . . . *Dissodinium*
Pyrocystis

1b. Cells motile in dominant stage 2

2a. Flagella insertion anterior, cell wall present in form of 2 longitudinal halves . . . . . *Prorocentrum*
(including *Exuviaella*)

2b. Flagella insertion not anterior, but usually 1 flagellum located in cingulum, the other partially in sulcus, mainly trailing behind cell 3

3a. Two valves (composed of plates, usually around 17), often flattened laterally, epitheca short, cingulum and sulcus usually with protrusive lists. 4

3b. Theca not oriented in opposing halves, rather composed of closely related plates in transversal series: apicals, precingulars, postcingulars, antapicals and intercalaries – or cell unarmored without this standard series 8

4a. Epitheca detectable above anterior cingular list, cingular lists horizontally extended . . . . . *Phalacroma*

4b. Epitheca not extensive above anterior cingular list 5

5a. Hypotheca posteriorly attenuated and long, usually with one terminal process, body at least 10X as long as broad. . . . . *Amphisolenia*

5b. Cell not as above 6

6a. Anterior cingular list less than 0.25X body width, left sulcal list usually not well developed . . . . . *Dinophysis*

6b. Cingulars lists quite wide, often anterior list funnel shaped, flared, posterior cingular list forms large "chamber", cingular lists supported by radial ribs, large posterior extension of left sulcal list present 7

7a. Posterior cingular list with less than 6 radial ribs . . . . . *Parahistioneis*

7b. Posterior cingular list with 6 or more radial ribs . . . . . *Ornithocercus*

8a. Cells unarmored or rather lacking external polygonal plates in standard series 9

8b. Cells armored, theca composed of plates in continuous or discontinuous series 22

9a. Cell with longitudinal premedian keel-like process, theca thick, reportedly not divided into standard plate series . . . . . *Ptychodiscus*

9b. No keel-like process 10

10a. Cytoplasm with internal radiating silicious, spinous structures. . . . . *Actiniscus*

10b. Cytoplasm without internal stellate structures. 11

11a. Body with tentacle or tentacular lobe, cingulum weakly defined 12

11b. Body without tentacle 14

12a. Tentacle anterior . . . . . *Pronoctiluca*

12b. Tentacle postmedian, extending posteriorly 13

13a. Large spherical cell, $\rangle$ 1,mm with relatively long tentacle, transverse flagellum reduced and modified . . . . . *Noctiluca*

13b. Cell smaller, $\langle$100 μ, transverse flagellum not rudimentary or reduced, body fusiform with short tentacular lobe . . . . . *Oxyrrhis*

14a. Cingulum distinctly premedian, epicone greatly reduced, hypocone predominant, cingulum completing one revolution . . . . . *Amphidinium*

14b. Cingulum slightly premedian, equatorial or postmedian, displaced or circular, completing one revolution or several (body torsion) 15

15a. Cingulum completing only one revolution 18

15b. Cingulum completing more than one revolution, a descending left spiral 16

16a. Cell with ocellus consisting of lens and melanosome 17

16b. Cell without ocellus . . . . . *Cochlodinium*

17a. Nematocysts present . . . . . *Nematodinium*

17b. Nematocysts not present . . . . . *Warnowia*

18a. Cingular area greatly postmedian, epicone exceeds hypocone 2X or greater 19

18b. Cingular area not decisively postmedian 20

19a. Cingulum and sulcus merge to form antapical loop, sulcus extending far into epicone . . . . . *Torodinium*

19b. Cingulum and sulcus do not merge posteriorly to form antapical loop . . . . . *Katodinium*

20a. Cingulum not displaced, or if displaced, not more than 1/5th body length 21

20b. Cingulum displaced more than 1/5th body length . . . . . *Gyrodinium*

21a. Motile cell single (unless dividing), division oblique, not pseudocolonial . . . . . *Gymnodinium*

21b. Motile pseudocolonial cell (incomplete fission), products stacked longitudinally . . . . . *Polykrikos*

22a. No defined cingulum, flagella undulates freely around cell body, not in furrow 23

22b. Defined cingular plate series indented, contains transverse flagellum 24

23a. Cell pear-shaped, apical region drawn out into short horn . . . . . *Podolampas*

23b. Cell without apical horn, body spherical to oval . . . . . *Blepharocysta*

24a. Plate patterns and/or surface markings discernible on intact, or cleared specimens under bright-field or phase-contrast microscopy 25

24b. Theca barely detectable, cell appears unarmored when intact, usually observed with partially exuviated theca arranged in separate plates at a discrete distance from cell . . . . . *Fragilidium*

25a. Separate plates indistinguishable in intact theca, masked by heavy surface reticulations . . . . . *Protoceratium*

25b. Individual plates usually distinguishable, sometimes apparent only after cell cleared of protoplasm 26

26a. Cell typically with 1 apical horn (or spatula-like epitheca) and 1-3 antapical short to long, hollow horns; very broad, hyaline ventral area . . . . . *Ceratium*

26b. Cell lacking horns as above and wide, hyaline ventral area 27

27a. Cell asymmetrically biconvex, longitudinal axis oblique, small, hypotheca appears as if without antapical plates . . . . . *Coolia*

27b. Cells variously shaped, at least one or more obvious antapical plates 28

28a. Consistently only one antapical accompanied by 0-1 posterior intercalaries 29

28b. More than one antapical plate 34

29a. Hypotheca with no posterior intercalaries 30

29b. Hypotheca with only one posterior intercalary 31

30a. Cell lenticular, flattened anteroposteriorly or rotund, posterior sulcal area with one wide conspicuous curved list . . . . . *Diplopsalis*

30b. Cell not flattened anteroposteriorly rather elongate, sharply pointed at the apices or biconical . . . . . *Oxytoxum*

31a. Cell broad, biconical, attenuated at apices, without antapical spines . . . . . *Spiraulax*

31b. Cells not attenuated, usually with posterior spines 32

32a. Hypotheca with prominent spines of varying lengths, theca generally thick and sculptured, cingulum extremely premedian . . . . . *Ceratocorys*

32b. Hypotheca not as above, cingulum slightly premedian, median or postmedian 33

33a. Theca very ornate with extensive apical and antapical winged spines, short apical protrusion, distinctive cingular lists . . . . . *Pyrodinium*

33b. Great range in morphology, with or without apical process, with or without antapical spines, cingulum displaced up to 6 widths . . . . . *Gonyaulax*

34a. Only 2 antapical plates 35

34b. More than 2 antapicals 36

35a. With 2-3 anterior intercalaries, morphology varied, 1st apical plate usually rhomboidal. . . . . *Peridinium*
Scrippsiella

35b. 0-1 anterior intercalaries, characteristic sulcal list wide, exceeding antapex, rudder-like . . . . . *Diplopsalis*

36a. Cell polyhedral to spherical, hypotheca with 3 antapical plates . . . . . *Heteraulacus*

36b. Cell biconvex, compressed anteroposteriorly, hypotheca with 3 or more antapicals . . . . . *Pyrophacus*

GENERIC DESCRIPTIONS AND SPECIES KEYS

Actiniscus (Ehrenberg) Ehrenberg, 1843

Type species: *A. pentasterias* (Ehrenberg) Ehrenberg, 1854

Unarmored, gymnodinioid body, cingulum not displaced or to 2.5X. Sulcus invades epicone and extends posteriorly onto dorsal surface. Characterized by presence of 1-8 large pentasters and up to 14 peripheral, modified pentasters (silicious wheel-like support structures). Observed with many refractive globules, a rod-like packet and strong pellicle. Organisms capable of encystment. Reported by Bursa (1969) to be phagocytic and have chloroplasts. Represented in the fossil record by silicious remains.

A. pentasterias (Fig. 1a, 1b)

Amphidinium Claparéde and Lachmann, 1859

Type species: *A. operculatum* Claparéde and Lachmann, 1859

Unarmored, with thin or thick pellicle, with or without markings such as ridges. Short epicone less than or about 1/3rd body length, cingulum distinctly premedian, with or without displacement (left-handed). Sulcus sometimes invading epicone. Body rotund, dorsoventrally flattened or laterally flattened, with or without chloroplasts. Some species toxic, associated with marine mortalities. Laterally flattened forms are primarily interstitial species, adapted to the environment (thick pellicle, compressed and modified sulcal area). Interstitial species exhibit diurnal and lunar (tidal) periodicity.

1a. Cell flattened dorsoventrally . . . . . *A. carteri* (Fig. 2a, 2b)

1b. Cell not flattened, rather round 2

2a. Cell with T-shaped junction of cingulum and sulcus . . . . . *A. crassum* (?)

2b. Cell with Y-shaped junction 3

3a. Epicone symmetrical, boundary continuous with hypocone, large expanded cell . . . . . *A. curcubita* (Fig. 3)

3b. Epicone asymmetrical and lobed, not ribbed, clearly separated from hypocone . . . . . *A. scissum* (?) (Fig. 4)

Amphisolenia Stein, 1883

Type species: *A. globifera* Stein, 1883

Armored, anterior process composed of "head" and "neck" regions followed by elongate body, midregion often swollen and containing nucleus. Antapex often in the form of a "foot" or "heel" with protrusions. Head and neck composed of very short epitheca (less than 1/10th body length) with cingular lists, usually supported by ribs, sulcal area with lists and the proximal part of an elongate hypotheca. Distal hypotheca in some species furcate. According to Tai and Skogsberg (1934): 5 epithecal plates, 4 cingular plates, 4 sulcal plates and 4 hypothecal plates. Many small plates in the sulcal area have various assignments which might be re-evaluated. Chloroplasts present.

1a. Hypotheca bi-furcate . . . . . *A. bifurcata* (Fig. 6a-6c)

1b. Hypotheca not furcate, relatively linear 2

2a. Hypotheca straight, with no antapical process . . . . . *A. truncata**

2b. Hypotheca with antapical process(es) 3

3a. Antapical process like webbed "foot" with spines . . . . . *A. bidentata* (Fig. 5a-5c)

3b. Antapical process box shaped with corner spinule . . . . . *A. rectangulata*

* *A. truncata* may represent a mutilated or aberrant form.

Blepharocysta Ehrenberg, 1873

Type species: *B. splendor-maris* (Ehrenberg) Stein, 1883

Armored, rotund, spheroidal to compressed. Sutures often difficult to determine, trichocyst pores at plate borders, when present, quite prominent. Cingulum not composed of plates, rather represented by a homologous cingular area where transverse flagellum undulates. Sulcal area typically with left and right lists. Cell body without elongate or obtrusive apical process. Most species without chloroplasts, cells observed phagocytizing other protists. Plate formula: 3', 1a, 5'', 4s, 3''', 3p and 2'''' (Abé, 1967) subject to various interpretations. For example, Balech (1963) recognizes three cingular plates which others interpret as postcingulars. Balech's formula: Po, 4', 1*a*, 5'', 3c, 4s, 3''' and 3''''. *Blepharocysta* and *Podolampas* no doubt should have a revised plate nomenclature, rather than accommodating to Kofoid's (1909).

1a. Cell flattened . . . . . *B. compressa* (Fig. 8)

1b. Cell not flattened, spheroidal to rotund 2

2a. One sulcal list in lateral view pointed, other list rounded . . . . . *B. paulsenii* (?)

2b. Both sulcal lists rounded, usually not reticulate . . . . . *B. splendor-maris* (Fig. 9a, 9b)

Ceratium Schrank, 1793

Type species: *C. pleuroceras* Schrank, 1793

Armored, a very diverse genus, represented by many species. Worldwide in occurrence, freshwater, brackish and marine. Characterized by 3-4 horns, 1 apical, 2 to 3 antapical, in the marine

habitat 2 antapical, 1 sometimes rudimentary. Some species with spatula-like epitheca and no apical horn. Plate formula: 4', 5'', 5''' and 2''''. Chloroplasts present. *Ceratium* unlike other armored dinoflagellates, has an obvious thecate ventral area (Figures 23c, 30d) composed of 4 plates occupying at least 2/3rds of the midbody's ventral surface. Some species such as *C. fusus* are bioluminescent under certain environmental conditions. Chain forming species occur with specially adapted horn trough for attachment. Some species are stenohaline or stenothermal to the extent of serving as indicator organisms for specific water masses. *Ceratium* can undergo autonomy for longer survival in the euphotic zone.

A key to only the subgenera *Archaeceratium*, *Ceratium* (=*Biceratium*), and *Amphiceratium*. The subgenus *Euceratium* would be an impossible task for this key because of morphological variability and the specific confusion that already exists.

0a. Antapical horns straight down or slightly curved and/or divergent, but not curved up past ventral area 1

0b. Antapical horns curved upward past ventral area . . . . . subgenus *Euceratium*

1a. One antapical horn rudimentary, barely detectable, spike-like 2

1b. Both antapical horns quite obvious, one may be shorter than the other 7

2a. Epitheca gradually tapered, not abruptly attenuated into horn. 3

2b. Epitheca abruptly attenuated 4

3a. Left antapical horn (longest) with distal curve or bend . . . . . *C. falcatum*

3b. Left antapical horn with gentle curve but not originating distally . . . . . *C. longirostrum* (Fig. 27)

4a. Long antapical horn with distal bend, proximal part of epitheca enlarged 5

4b. Long antapical horn with gentle curvature whole length, or straight 6

5a. Proximal part of epitheca greatly expanded . . . . . .*C. bigelowii* (Fig. 11a, 11b)

5b. This area only slightly inflated . . . . . *C. inflatum* (Fig. 25)

6a. Cell extremely long, about 1000 μ or more, left antapical horn usually straight . . . . . *C. extensum* (Fig. 19)

6b. Cell shorter, less than 800 μ, left antapical horn usually with gentle bend to entire horn . . . . . *C. fusus* (Fig. 21a, 21b)

7a. Epitheca twisted, entire cell appears boot-shaped . . . . . *C. schroteri* (Fig. 154)

7b. Cell not boot-shaped 8

8a. Body broadly pentagonal, antapical horns short, midbody as broad as long . . . . . *C. pentagonum* (Fig. 31)

8b. Body not necessarily pentagonal, midbody breadth not equal to length 9

9a. Antapical horns moderately short, midbody much broader than long, cell appears chair shaped (or small h-shaped), chain forming species . . . . . .*C. candelabrum* var. *depressum* (Fig. 153)

9b. Midbody region longer than broad 11

10a. Antapical horns almost equal, right directed ventrally . . . . . *C. hircus* (?) (Fig. 24a, 24b)

10b. One antapical horn, usually the right, decidedly shorter than the other 11

11a. Epitheca gradually tapered, not abruptly attenuated, antapical horns parallel to slightly divergent 12

11b. Epitheca abruptly attenuated into apical horn 13

12a. Thick walled cell with almost straight-sided epitheca, body almost as wide as epitheca, antapical horns parallel . . . . . *C. belone* (Fig. 10)

12b. Epitheca not as wide as body, with antapical horns more divergent . . . . . *C. furca* (Fig. 20a, 20b)

13a. Cell delicate, antapical horns finely pointed and smooth . . . . . *C. kofoidii* (Fig. 26)

13b. Cell sculptured 14

14a. Cell body rounded in ventral view, not angular, antapical horns proximally constricted, spinous . . . . . *C. teres* (Fig. 35a, 35b)

14b. Cell midbody more angular 15

15a. Short, squat body with short, nearly parallel, antapical horns . . . . . *C. minutum*

15b. More elongate body with divergent antapical horns . . . . . *C. lineatum*

Ceratocorys Stein, 1883

Type species: *C. horrida* Stein, 1883

Armored, hypotheca with prominent spines, angular to rotund body. Cingulum usually anterior and displaced at least one width, without overhang. Cingulum lists well developed, supported by ribs. Posterior cingular list without submarginal rib and with 6 or more radial ribs. Theca usually pitted and porous. Plate formula: 4', 0*a*, 5", 6c(?), 5-6s, 5-6‴, 1*p* and 1⁗. Other interpretations of the epithecal series in past literature: 2', 2*a* and 5" or 3', 1*a* and 5". Chloroplasts present. Spineless, less rugose forms have been observed (nature and culture) as developmental stages from excystment.

1a. In addition to 4 spines on antapical plate, 1 ventral and 1 dorsal spine (winged), spines usually as long or longer than body . . . . . *C. horrida* (Fig. 42a-42d)

1b. Only 4 antapical spines, very much reduced . . . . . *C. armata* (Fig. 41a, 41b)

Cochlodinium Schütt *in* Engler and Prantl, 1896

Type species: *C. strangulatum* (Schütt) Schütt *in* Engler and Prantl, 1896

Unarmored, gyrodinioid form with cingular rotation greater than 1X. Body appears twisted. No nematocysts or ocelli present. With or without chloroplasts. Encystment common.

C. citron (Fig. 43)

Cochlodinium A (Fig. 44)

Cochlodinium B (Fig. 45)

Coolia Meunier, 1919

Type species: *C. monotis* Meunier, 1919

Past and present synonymy with *Ostreopsis* unwarranted because of plate and structural differences. Armored, cell lenticular ventrally, asymmetric laterally with oblique axis. Anterior intercalary with pore. Cingulum median. Plate formula: 3', 0*a*, 7'', 6 (7?) c, 5''', 0*p* and 0'''' or 2'''' depending on interpretation of sulcal area. Chloroplasts present.

C. monotis (Fig. 82)

Dinophysis Ehrenberg, 1839

Type species: *D. acuta* Ehrenberg, 1839

Armored, laterally compressed cells with conspicuous cingular lists. Anterior cingular list broadly funnel shaped extending beyond the epitheca which is relatively short, at times barely detectable. Hypotheca usually exceeds epitheca by at least 6X. Cingulum distinctly premedian and unusually of even width. Sulcal lists prominent, often resembling wings, supported by ribs, with or without simple posterior "sails". Plate formula: 5 epithecal plates, 4 cingular plates, 4 sulcal plates and 4 hypothecal plates. Chloroplasts usually present.

1a. Hypotheca with posterior sail . . . . . *D. hastata* (Fig. 48)

1b. Hypotheca without posterior sail, hypotheca may be rounded or drawn out into protuberance 2

2a. Hypotheca with distinctive protuberance, pendulate or V shaped, but not rounded . . . . . *D. caudata**

2b. Hypotheca rounded 3

3a. Sulcal list extending beyond midpoint of body . . . . . *D. fortii*

3b. Sulcal list not extending beyond midpoint of body . . . . . *D. ovum*(?) (Fig. 49)

* Three varieties were recognized as belonging to the species: var. *acutiformis* (Fig. 46), var. *diegensis* and var. *pedunculata* (Fig. 47).

Diplopsalis Bergh, 1881

Type species: *D. lenticula* Bergh, 1881

Armored, body lenticular to subspherical, prominent left sulcal list curved beyond hypotheca. Cingulum not displaced, usually equatorial. Very similar to the genus *Peridinium*, possible synonymy in this group. Plate formula: 3-4', 1-2*a*, 6-7'', 5''', 0*p* and 1-2''''. Chloroplasts absent.

1a. Body lenticular 2

1b. Body somewhat rounded, with slight apical process . . . . . *D. rotundata (=Oblea rotundata)*

2a. Plate tabulation with only 1 antapical 3

2b. 2 antapical plates . . . . . *D. lenticula* f. *asymmetrica* (Fig. 52)

3a. 3 apical plates and 1 anterior intercalary . . . . . *D. lenticula* (Fig. 51)

3b. 4 apical plates and 1 anterior intercalary . . . . . *D. lenticula* f. *minor* (Fig. 53)

Dissodinium Klebs *in* Pascher, 1916

Type species: *D. lunula* (Schütt)Klebs *in* Pascher, 1916

Unarmored, small gymnodinioid reproductive stage, with various cystic life stages including stage I which is spherical (⟨200 μ) and stage V which is broadly crescent shaped. Cystic stages non-motile, usually found floating. Chloroplasts present.

D. lunula (Fig. 55a, 55b)

Fragilidium Balech *ex* Loeblich III, 1965

Type species: *F. heterolobum* Balech *ex* Loeblich III, 1965

Armored, round in cross section, somewhat biconical. Cingulum area with many plates. 1st apical not in contact with cingulum. Characterized by rapid exuviation of theca and retention of plates at a discrete distance from cyst. Plate formula: 4', 9'', 12c, 6s, 7''', 1*p* and 2'''', depending on interpretation of antapical series. Chloroplasts present.

Fragilidium sp. (Fig. 56)

Glenodinium Ehrenberg, 1837

Type species: *G. cinctum* Ehrenberg, 1837

Delicately armored, gymnodinioid type cell, roundish to ovoid. Plates difficult to see even in cleared specimens. Most species from brackish and fresh waters. Dubious plate formula: 3-5', 0-4*a*, 6-7'', 3-5''', and 2''''. Cells usually with chloroplasts. Difficult genus to describe because of past synonymy and inadequate observational techniques; perhaps some species should be included under *Peridinium* as Wood (1968) suggested. See Prager (1963) for a discussion of *Glenodinium* and the removal of the family Glenodineaceae.

Glenodinium B (Fig. 57)

Gonyaulax Diesing, 1866

Type species: *G. spinifera* (Claparède and Lachmann) Diesing, 1866

Armored, variable genus in shape and dimensions, spherical to top-shaped. Cingulum always displaced, usually greater than 1 cingulum width, occasionally 3 to 6 widths, with or without overhang. Body smooth with no markings (light microscopy) to rugose with reticulations, pits, striae, occasionally with antapical spines. 1st apical plate can be sigmoid and narrow, straight and narrow, or typically rhomboidal, like *Peridinium*. Plate formula: 3-5', 0-4*a*, 6'', 6c, 6-7s, 6''', 1*p* and 1''''. Chloroplasts present. Bioluminescent and toxic marine species known.

1a. Cells catenate, anterior and posterior attachment pores . . . . . *G. monilata* (Fig. 62a, 62b)

1b. Cells not catenate, single or 2 cells attached 2

2a. Cell with longitudinal or nearly longitudinal striae. 3

2b. Without longitudinal striae 6

3a. Cell with apical process or modification. 4

3b. Without apical process (horn). 5

4a. Apical horn long (⟩6 μ), epitheca tapered, 2 or more antapical spines, rugose cell, heavily reticulated . . . . . *G. polygramma* (Fig. 64a-64c)

4b. Apical protrusion very short (<4 μ), epitheca almost rounded, less rugose . . . . . *G. turbynei* (Fig. 65a, 65b)

5a. Cell very broad, as wide as long . . . . . *G. hyalina*

5b. Cell longer than broad, elongate closing platelet on dorsal side. . . *G. fragilis* (Fig. 61a-61c)

6a. Cingulum usually with overhang, displaced 2-3X or more, right side quite convex ventrally 7

6b. *Cingulum* without overhang 9

7a. Cell with well developed apical horn, body large, greater than 60 μ . *G. digitalis* (Fig. 60a, 60b)

7b. Cell smaller, without large horn, rather slight protuberance or moderate horn 8

8a. Cell rotund, overhang minimal, hypotheca rounded without spines . . . . . *G. scrippsae*

8b. Cell with moderate horn, body slightly elongate, usually 2 antapical spines . . . . . *G. spinifera*

9a. Body shape polyedral, without antapical spines, theca pitted . . . . *G. polyedra* (Fig. 63)

9b. Not as above 10

10a. Cingulum displacement greater than 3X . . . . . *G. diegensis* (Fig. 59a, 59b)

10b. Cingulum displacement less than 3X 11

11a. 1st apical plate not in contact with closing platelet . . . . . *G. monilata*

11b. 1st apical in contact with closing platelet 12

12a. Epitheca conical, theca delicate, 2 antapical spines, body compressed dorso-ventrally . . . . . *G. diacantha* (Fig. 58a, 58b)

12b. Epitheca not conical, body rotund . . . . . *Gonyaulax* sp. (Fig. 66)

Gymnodinium Stein, 1878

Type species: *G. fuscum* (Ehrenberg) Stein, 1878

Unarmored forms, varied morphology from spherical to biconical and lobed. Cingulum usually equatorial or premedian, with or without displacement. If displaced, less than 1/5th body length. Sulcus often invading epicone. Cells small (<10 μ) to large (>200 μ); color: green, yellow, brown, blue or pink. With or without chloroplasts. Some species toxic. Refer to the section on Taxonomic Problems for suggested alternate characters.

1a. Cingulum barely distinct, equatorial, cell small (<20 μ), chloroplasts few . . . . . *G. simplex*

1b. Cingulum displaced 1X or greater 2

2a. Cell with distinct pellicular ridges, protoplasm often blue, green, pink, or yellow, body 1/2 wide as long . . . . . *G. coeruleun* (Fig. 68a, 68b)

2b. Pellicle not striated or ridged 3

3a. Sulcus extends into epicone 6

3b. Sulcus does not enter epicone . . . . . *G. splendens** (Fig. 69a-69d)

4a. Sulcus in epicone directed to the left side. . . . . *G. breve* (Fig. 67)

4b. Sulcus directed to the right . . . . . *G. incisum*

Many small *Gymnodinium* (⟨10 species) were not identified in this study, but most *Gymnodinium* over 30 μ were either identified or designated with letters, *i. e.*, E, I, J, etc. These designations (5) are not in the key.

*This form of *G. splendens* has been identified by some researchers as *G. nelsonii*, which was considered by Kimball and Wood (1965) to be a life stage of another dinoflagellate.

Gyrodinium Kofoid and Swezy, 1921

Type species: *G. spirale* (Bergh) Kofoid and Swezy, 1921

Unarmored, most cells fusiform or biconical, others ovoid and flattened dorso-ventrally and yet others of varied form. Cingulum always displaced 1/5th total length or greater, with or without overhang. Sulcus often invading epicone. Cells small (⟨20μ) to large (⟩100μ). Varied pigmentation and nutrition. Refer to the section on Taxonomic Problems for possible alternate characters.

1a. Pellicle distinctly ridged, body fusiform, cingulum displaced ⟩6X, anterior body sometimes curved slightly or twisted . . . . . *G. spirale*

1b. Pellicle not ridged, either striated or apparently smooth 2

2a. Cell with anterior and/or posterior sac-like protrusions or contracted lobular apices, pellicle not striated 3

2b. Cell subovoidal, some lateral compression, posterior lobes overlap, cingulum greatly displaced . . . . . *G. fissum* (Fig. 74)

3a. Cell spindle shaped, irregular, sulcal area wide . . . . . *G. falcatum* (Fig. 73a, 73b)

3b. Cell fusiform, short lobular apices, cingulum with slight overhang. . . . . *G. caudatum*

Many *Gyrodinium* species (⟨10) were not identified in this study. Often forms resembling *G. pinque* were dominant.

Heteraulacus Diesing, 1850

Type species: *H. acuminatus* (Ehrenberg) Diesing, 1850 (=*Goniodoma polyedricum*)

Armored, cell polygonal, rounded or ovoid. Cingulum equatorial or nearly so. Apical closing platelet present, theca usually thick and heavily sculptured with pits and/or striae. Plate formula: 3-4', 7", 6c, 5''' and 3''''. Chloroplasts present.

1a. Cell polyedrical, angled theca with abbreviated plate lists . . . . *H. acuminatus* (Fig. 76a-76f)

1b. Cell somewhat spheroidal, no body lists, smooth contour . . . . . *H. sphaericus* (Fig. 77)

Katodinium Fott, 1957

Type species: *K. nieuportensis* (Conrad) Loeblich and Loeblich, 1967

Unarmored, gymnodinioid cell with cingulum greatly postmedian, often difficult to delineate.

Cells pear-shaped, pendulate or club-shaped. Epicone exceeding hypocone by 2X. With or without chloroplasts.

K. rotundatum

K. glaucum

Kofoidinium Pavillard, 1928

Type species: *K. velleloides* Pavillard, 1928

Unarmored, adult – large inflated Amphidinium-like with short epicone and long, broad hypocone. Later stages characterized by hypoconal velum. Phagocytic organisms characterized by cytosome (epicone), cytopharynx, and pusule, with large central mass of protoplasm. Known to go through various stages of development, e.g., in *K. pavillardii*, six stages are recognized. Some stages resemble *Gymnodinium. Amphidinium* and noctilucoid forms. No chloroplasts. Some life stages previously synonymized with *Gymnodinium pseudonoctiluca.*

K. pavillardii (Fig. 78a, 78b)

Nematodinium Kofoid and Swezy, 1921

Type species: *N. partitum* Kofoid and Swezy, 1921

Unarmored, gyrodinioid but with more than one turn of the cingulum, body appears twisted. Sulcus ends on dorsal surface near antapex. Characterized by presence of nematocysts and ocellus. Chloroplasts absent.

Nematodinium spp.

Noctiluca Suriray *in* Lamarck, 1816

Type species: *N. miliaris* Suriray *in* Lamarck, 1816

Unarmored, one of the largest dinoflagellates known, body usually spherical to slightly reniform. Cingulum indistinguishable, sulcus deep with longitudinal flagellum short. Posterior tentacle characteristic. Protoplasm radially stranded, nutrition holozoic. Reproduces by zoospores.

Not taken in Hourglass collections.

Ornithocercus Stein, 1883

Type species: *O. magnificus* Stein, 1883

Armored, body urn-shaped, compressed laterally, similar to *Dinophysis.* Cingular lists long (up to 1 1/4X body width), usually flared and broad, supported by ribs. Anterior cingular list funnel-shaped. Body with rib-supported left sulcal list that usually extends past the antapex and is quad-lobed or crested. Plate formula: 4 epithecal plates, 1 pore plate, 4 cingular plates, 4 sulcal plates, and 4 hypothecal plates (Norris, 1969). Chloroplasts absent.

1a. 1st prominent left sulcal list rib (R_3) L-shaped sometimes with spur . . . . . *O. magnificus* (Fig. 79a, 79b)

1b. R_3 not as above, cingular list ribs more numerous 2

2a. Left sulcal list with 3 distinct posterior lobes or crests . . . . . *O. thumii* (Fig. 81)

2b. Left sulcal list with more than 3 lobes or crests or barely lobed at all . . . . . *O. steinii* (Fig. 80)

Oxyrrhis Dujardin, 1841

Type species: *O. marina* Dujardin, 1841

Unarmored, body oval. Cingular and sulcal areas reduced, cingulum incomplete, sulcus interrupted by tentacular lobe directed posteriorly. Small cell, less than 50 μ. Chloroplasts absent.

O. marina (Fig. 83)

Oxytoxum Stein, 1883

Type species: *O. scolopax* Stein, 1883

Armored, body spindle-shaped to top-shaped, hypotheca exceeds epitheca by at least 2/3rds, apices usually pointed or attenuated. Theca delicately or rugosely marked with linear striae or ridges, often pitted. Plate formula: 3', 2a, 6", 6c, 4-5(?)s, 5''' and 1'''', depending on interpretation. Chloroplasts usually present.

1a. Large cell, 〉200 μ long, with longitudinal distinctive longitudinal hook-and-eye striae . . . . . *O. gigas* (Fig. 85a-85c)

1b. Smaller cell without hook-and-eye striae 2

2a. Epitheca at cingulum as wide or almost as wide as hypotheca 3

2b. Epitheca much narrower than hypotheca (〈1/2 width) at cingulum, cingular area neck-like . . . . . *O. scolopax* (Fig. 87)

3a. Surface markings not cross-hatched, epitheca long and dagger-like . . . . . *O. milneri* (Fig. 86)

3b. Hypotheca with longitudinal and horizontal cross-hatched markings 4

4a. Epithecal ridges serrated, drawn out into point . . . . . *O. elegans* (Fig. 84)

4b. Epitheca conical without prominent serrated apex . . . . . *O. tesselatum* (Fig. 88)

Parahistioneis Kofoid and Skogsberg, 1928

Type species: *P. diomedeae* (Kofoid and Michener) Kofoid and Skogsberg, 1928

Armored, body generally longer than deep, compressed laterally, epitheca short. Cingulum wider dorsally. Anterior cingular list funnel-shaped, flared. Posterior cingular list collar-shaped with less than 6 radial ribs, no submarginal cross rib. Left sulcal list with only one posterior lobe. Like other Dinophysoidae, this genus probably has 5 epithecal plates, 4 cingular plates, 4 sulcal plates and 4 hypothecal plates.

Parahistioneis sp. (Fig. 166)

NOT IN HOURGLASS MATERIAL

Peridinium Ehrenberg, 1832

Type species: *P. cinctum* (O. F. Muller) Ehrenberg, 1832

Armored, body shape varied. Epitheca usually with an apical platelet, many species with apical and antapical horns. Cingulum generally equatorial with or without displacement, some species with

overhang. Cingulum displacement can be either ascending or descending. Surface markings varied from pits to knobs. Shapes of plates 1' and 2*a* diagnostic to group. Plate formula: 4' 2-3*a* 7", 4-6c, 4s, 5''' and 2''''. The majority of species lack chloroplasts.

No key to Hourglass species is presented because of species variation and the uncertainty of generic assignments.

Phalacroma Stein, 1883

Type species: *P. prodictyum* Stein, 1883

Armored, composed of several opposing plates, cingulum distinctly premedian usually with the epitheca detectable above the anterior cingular list. Cingular lists generally directed horizontally rather than funnel-shaped. Tag and Skogsberg (1928) gave the following plate account: 5 epithecal plates, 4 cingular plates, 4 sulcal plates and 4 hypothecal plates. Chloroplasts usually present.

1a. Epitheca greater than 1/4th cell length 2
1b. Epitheca less than 1/4th cell length 3
2a. In lateral view, cingulum centrally dipped, cell ovoid. . . . . *P. argus* (Fig. 121)
2b. Cingulum not dipped, rather straight in lateral view . . . . . *P. apicatum* (Fig. 120)
3a. Cell shape round . . . . . *R. rotundatum* (Fig. 124)
3b. Cell shape other than round 4
4a. Hypotheca with antapical lobe 5
4b. Hypotheca without lobe, rather cell cup-shaped . . . . . *P. cuneus* (Fig. 122)
5a. Hump located at termination of sulcal lists . . . . . *P. rapa* (Fig. 123)
5b. No hump in lateral view . . . . . *P. mitra*

Abé (1967b) and Balech (1967b) have both recently combined the genera *Phalacroma* and *Dinophysis* under the latter generic name.

Podolampas Stein, 1883

Type species: *P. bipes* Stein, 1883

Armored, top-shaped to pear-shaped with tapered apical horn. Body with 1 or 2 winged antapical spines. No cingulum as such, but a median cingular area with a transverse flagellum. Chloroplasts absent. This genus, like *Blepharocysta*, is given a plate formula according to the standard series: 3' 1*a*, 5", 4s, 3''', 3*p* and 2'''' (Abé, 1966), depending on interpretation of the plate sequences. Balech (1963) recognizes a cingular plate series (3c) and the formula: Po, 4', 1*a*, 5", 3c, 4s, 3''' and 3''''.

1a. Cell with 1 long antapical wing process and 1 anterior spine atop the long apical horn . . . . . *P. spinifer* (Fig. 129)
1b. Cell with 2 prominent antapical wing processes 2
2a. Cell narrow, less than 30 μ 3
2b. Cell wider, greater than 30 μ 4
3a. Antapical processes almost equal . . . . . *P. elegans* (Fig. 127)
3b. Antapical processes distinctly subequal . . . . . *P. palmipes* (Fig. 128a, 128b)

4a. Antapical wing processes serrate and reticulate, body very broad . . . . . *P. reticulata* (Fig. 126a, 126b)

4b. Antapical wing processes smooth, body not as broad . . . . . *P. bipes* (Fig. 125)

Polykrikos Bütschli, 1873

Type species: *P. schwartzii* Bütschli, 1873

Unarmored, a pseudocolonial genus composed of 2 to 16 Gymnodinium-like components (zooids) closely appressed longitudinally without cellular septations, each component with its own cingulum but all sharing a common continuous sulcus. Genus sometimes considered colonial. Those species with more than 2 zooids usually with 1 nucleus per 2 zooids. With or without chloroplasts, nematocysts, cingulum displacement or body twist, noted to phagocytize *Ceratium, Peridinium, Gonyaulax* and other phytoplankters.

1a. Cell with chloroplasts . . . . . *P. hartmannii* (Fig. 130)

1b. Cell without chloroplasts 2

2a. Cell with hypoconal ridges, most obvious in antapical view . . . . . *P. kofoidii*

2b. Cell without hypoconal ridges . . . . . *P. schwartzii** (Fig. 131a, 131b)

* Our *P. schwartzii* cells do not agree with typical descriptions: the cell has a slight twist, concave in the sulcal area, cingulum displaced 1-2 widths, but otherwise characteristic and without hypoconal ridges.

Pronoctiluca Fabre-Domergue, 1889

Type species: *P. pelagica* Fabre-Domergue, 1889

Unarmored, oblong with cingulum decidedly premedian, accompanied by a flexible anterior tentacle. Chloroplasts absent. Small, difficult to distinguish alive.

P. acuta (Fig. 132a, 132b)

Prorocentrum Ehrenberg *ex* Abé, 1967

Type species: *P. micans* Ehrenberg, 1834

Armored, but composed of 2 opposing valves, with or without apical teeth or protrusions, but with apical platelet. Valves typically with poroids, pores, reticulations, spines or other surface markings. Cells usually compressed laterally and with chloroplasts. Variously shaped from oval to almost circular.

1a. Cell heart-shaped, longitudinally arced or posteriorly pointed 2

1b. Cell more ovoid 8

2a. Cell usually with one apical tooth (varies in length) dagger-shaped on right valve, body heart-shaped 3

2b. Cell either with arced body or with 2 apical teeth, 1 on each valve, or with apical invaginations 6

3a. Cell broad and large (ca. 50 μ long) . . . . . *P. micans* (Fig. 136a, 136b)

3b. Cell smaller. 4

4a. Cell resembling *P. micans*, but narrower or shorter 5

4b. Cell occasionally with short tooth, valves with spines detectable at high magnification . . . . . *P. scutellum*

5a. Cell less broad, occasionally with posterior indentations (marginal) . . . . . *P. gracile* (Fig. 134a-134c)

5b. Cell smaller, about 15-20μ long . . . . . *P. triestinum* (Fig. 170)*

6a. Cell without tooth, body apex invaginated . . . . . *P. pyriforme* (Fig. 137)

6b. Not as above 7

7a. Valves drastically arced in midregion . . . . . *P. arcuatum*

7b. Valves not arced, narrow, pointed posteriorly with 1 apical tooth on each valve, tooth broad . . . . . *P. rostratum* (Fig. 138)

8a. Valves usually with short anterior processes either one or two horizontally opposed 9

8b. Cell without anterior protrusions or processes 10

9a. Cell flattened, more oblong with 1 short anterior process, trichocyst pores in few linear rows posteriorly, diagonally directed . . . . . *P. maximum* (Fig. 135)

9b. Cell only slightly compressed with 2 anterior processes directed like pincers . . . . . *P. compressum* (Fig. 133)

10a. Valves without any visible surface markings, unless marginal striae, or interior conical depressions . . . . . *P. aporum*

10b. Cells with detectable markings 11

11a. Both valves with conical depressions, centrally located . . . . . *P. perforatum*

11b. Not as above 12

12a. Cell like *P. aporum* but smaller (<20 μ) with surface markings . . . . . *P. mariae-lebourae*

12b. Cells more oblong and broad 13

13a. Cell broader posteriorly, anterior depressed . . . . . *P. marinum*

13b. Cell not broader posteriorly, anterior with slight invaginations, not merely depression . . . . . *P. oblongum*

*Not in Hourglass Material.

Abé (1967a) combined the genera *Exuviaella* Tsenkovskiy with *Prorocentrum*, a revision accepted in this systematic account.

It would be difficult to portray species by markings because their true identity (markings) is unknown. Appearance under light microscopy may differ from actual ultrastructure. Therefore in this present account, markings are presented as they appear under light microscopy.

Protoceratium Bergh, 1881

Type species: *P. aceros* Bergh, 1881

Armored, cell ovoid to spheroid, usually slightly angular. Theca strongly reticulated or aerolated, obscuring suture lines, difficult to interpret plate pattern. Plate formula: 2', 6", 6‴, 1*p* and 1⁗. Chloroplasts present.

P. reticulatum (Fig. 140a-140c)
P. aerolatum

Ptychodiscus Stein, 1883

Type species: *P. noctiluca* Stein, 1883

Unarmored, characters not well known with the exception of a distinguishing keel-like process at the apex. Cingulum apparently not displaced, hypotheca exceeds epitheca. Discoid, lenticular or gymnodinioid-like body, depending on treatment. Boalch (1969) recently synonymized all described species of this genus under *P. noctiluca*. Chloroplasts reported by Balech (1967b).

P. noctiluca (Fig. 141)

Pyrocystis Thomson *in* J. Murray, 1876

Type species: *P. fusiformis* Thomson *in* J. Murray, 1876

Unarmored, protoplasm stranded radially, otherwise hyaline cell. Shaped from spherical to antler-like (acutely crescent). Non-motile, floating in dominant stage, reproduces by spores resembling dinoflagellates such as *Gymnodinium*. Chloroplasts present.

1a. Cell spherical, large >200 μ . . . . . *P. pseudonoctiluca* (Fig. 143)

1b. Cell fusiform or biconical 2

2a. Cell fusiform . . . . . *P. fusiformis* (Fig. 142)

2b. Cell biconical . . . . . *P. fusiformis* f. *biconica* (Fig. 144)

Pyrodinium Plate, 1906

Type species: *P. bahamense* Plate, 1906

Armored, body almost spherical to compressed anteroposteriorly. Most characteristic aspect is complex wing system extending from broad apical process to antapical spines. Theca thick and strongly sculptured. Cingulum displaced without overhang. 1st apical plate offset from apex. Plate formula: 4', 6'', 6c, 5s, 6''', 1*p* and 1'''' (Wall and Dale, 1969). Chloroplasts present.

P. bahamense (Fig. 145)

This genus requires much work concerning the plate formula and re-evaluation of generic characters. *P. schilleri* probably should be *P. bahamense* f. *compressa* Bohm.

Pyrophacus Stein, 1883

Type species: *P. horologium* Stein, 1883

Armored, cell flat, biconvex lens-shaped to asymmetrically biconvex. Cingulum not displaced. Epitheca equal or exceeding hypotheca. Theca striated and poroid. Plate formula: 5-7', 0-1*a*, 9-13'', 9-13''', 0-1*p* and 4-8''''. Steidinger and Davis (1967) reported on *Pyrophacus* B_1, an ecoform with the plate formula: 7-9',2-8*a*, 13-15(16?)'', 13-16''', 0-6*p* and 7-11''''.

P. horologium (Fig. 146a, 146b)

P. horologium var. *steinii* (Fig. 147)

One ecoform (*Pyrophacus* B_2) has been tabulated with 8', 27*a*, 22'', 21''' and 35 other hypothecal plates. Consequently, all those forms with more than 5' 0a, 9'', 9''', 0*p* and 4'''' are possibly ecoforms of *P. horologium*. The standard plate formula covers the two common forms encountered locally; however, a form with 6-7', 0-1*a*, 11-13'', 11-13''', 0-1*p* and 5-8'''' encountered in Gulf and

contiguous waters was previously reported by our Laboratory as *P. horologium* var. *steinii* and remains so in this report.

Torodinium Kofoid and Swezy, 1921

Type species: *T. teredo* (Pouchet) K foid and Swezy, 1921

Unarmored, cigar-shaped body, epicone exceeds hypocone (>5X), sulcus extends almost entire length of cell. Sulcus and cingulum join posteriorly to form antapical loop. Chloroplasts green to brown.

1a. Cell length >3X width, sluggish swimmer, usually with brown chloroplasts . . . . . *T. teredo* (Fig. 150)

1b. Cell length 3X width or less, translucent cell with green pigment . . . . . *T. robustum* (Fig. 149)

Warnowia Lindemann *in* Engler and Prantl, 1928

Type species: *W. fusus* (Schütt) Lindemann *in* Engler and Prantl, 1928

Unarmored, gyrodinioid with more than one turn of the cingulum (1-2), body appears twisted. Characterized by ocellus usually positioned posteriorly. Lacks nematocysts and chloroplasts.

Warnowia A (Fig. 151a, 151b)

TAXONOMIC PROBLEMS

With the exploitation of electron microscopy and the resolution of dinoflagellate fine structure, it has become apparent that the artificial separation "naked" vs. "armored" is not satisfactory. Dodge (1967) and Dodge and Crawford (1968) have illustrated this point well with their observations on cell wall structure of *Amphidinium carteri* and *Aureodinium pigmentosum*. *Amphidinium carteri* was shown to be thecate, not naked as previously resolved by light microscopy. The theca is composed of hyaline polygonal plates not serially arranged. *Aureodinium pigmentosum* could, under light microscopy, be classified as naked but this species has a thecal arrangement of polygonal plates. New techniques and advanced studies may show that the majority of dinoflagellates are thecate. This possibility has been suggested before in regard to some marine *Gymnodinium* (Biecheler, 1952) and *Woloszynskia* (Bursa, 1958). *Woloszynskia* has long been recognized as having a reticulate hyaline theca of many polygonal plates not arranged in specific series. Bursa (1958) suggested that the various cell membrances represented developmental phases. *Woloszynskia, Aureodinium,* and *Gymnodinium* may be synonymous. The plate arrangement of such species can still be differentiated from those more heavily thecate (armored) where the cell wall is composed of specific plate series. Therefore, the distinction should not be naked vs. armored, but unarmored (either naked or thecate) vs. armored.

Recent confirmation of this viewpoint was made by Dodge and Crawford (1969) in their ultrastructural survey of dinoflagellate thecae. These authors were able to separate eight distinct groups: "1) Outer membrane underlain by irregular vesicles. 2) Membrane underlain by close-packed vesicles. 3) As Group 2 but with plug-like structures attached to the inner membrane of the vesicles.

4) As Group 2 but with thin plates within the vesicles and all plates of more or less similar shape. 5) As Group 4 but plates have slight overlap. 6) Similar to Group 5 but plates are reduced in number and can be individually recognized. 7) As Group 6 but plates have elaborate flanges and their surfaces are covered by reticulations. 8) Theca mainly consisting of only two plates."

From these separations, a possible revision of the Dinophyceae was proposed. The revision would delineate five groups: 1) No distinct plates in theca (e.g., *Amphidinium, Noctiluca, Nematodinium, Oxyrrhis*). 2) Theca of thin polygonal plates (e.g., *Gymnodinium, Woloszynskia, Gyrodinium, Aureodinium, Katodinium*). 3) Theca of thick plates, each with distinguishable shape (e.g., *Glenodinium, Gonyaulax, Heterocapsa, Peridinium* [perhaps *Scrippsiella* instead]). 4) Theca of thick plates covered by reticulations (e.g. *Peridinium, Ceratium*). 5) Theca of 2 valves (e.g. *Prorocentrum*).

The concept of unarmored vs. armored for *Gymnodinium, Gyrodinium* and *Polykrikos* is important structurally, but since electron microscopy is necessary for this determination, its taxonomic value at the generic level and lower is reduced. The ecologist working with many fresh samples over short periods of time does not have the facilities or the time to study fine wall structure. The needs at this time are for more reliable characters for differentiation of these groups under light microscopy.

Polykrikos has been considered colonial, being composed of Gymnodinium-like "zooids" that have remained attached after division. Steidinger, Davis and Williams (1967b) however, characterized the genus as pseudocolonial, whereby the "zooids" contribute to the morphology and cytology of one cell and not an aggregate of 2 to 16 individuals. We believe that the cell lacks septations and that the zooids are enclosed by a common pellicle. Davis (1955) referred to this type of cellular orientation as syncytial, one cell having two or more nuclei, without evidence of cellular septations. Electron microscopy would elucidate this type of organization if preparatory techniques were more adequate for unarmored flagellates. If this genus is more correctly described as pseudocolonial or a syncytium, then the description for the motile, free-living Dinophyceae/Dinoflagellida should be expanded to include: pseudocolonial individuals with 4 to 32 flagella and more than one nucleus (2 to 8).

Gymnodinium breve, one of Florida's Red Tide organisms, has been observed frequently and its morphology continually scrutinized (Steidinger and Williams, 1964; Dragovich, 1967; Wilson, 1967). Culture studies corroborate observations on the changing morphology of this species in natural populations. Davis (1948) originally described *G. breve* without cingulum displacement, the nucleus located centrally, and without strong ventral concavity. Specimens from 1965-1968 had a cingulum displacement of 2X, the nucleus located in the lower left quadrant and a strong ventral concavity accompanied by dorsal convexity. Specimens in a given population can be assigned to *Gymnodinium* or *Gyrodinium* depending on the extent of cingulum displacement. Cingulum displacement of recently examined specimens was definitely descending (lefthanded), while specimens observed by Steidinger and Williams (1964) in a north Florida Red Tide, had either descending or ascending cingulums. This alteration in character is probably influenced by the concavity and the change in nuclear position, thus affecting the angle of division. Such observations have been previously reported by Bursa (1962) in cultures of *Gyrodinium californicum*.

The genera *Gymnodinium* and *Gyrodinium* are usually separated by the extent of cingulum displacement. *Gymnodinium* has no displacement or only slightly left-handed, not more than 1/5th total cell length. *Gyrodinium* has a cingulum displacement of more than 1/5th. Outline characters are of little use because of the wide morphological diversity in both genera. Therefore, a finer distinction must be made to separate the two genera. *Gymnodinium* and *Gyrodinium* both include species that have the sulcus invading the epicone as well as species without the sulcus on the epicone. The following three possibilities appear to be the most logical solutions to this problem: 1)

those species with the sulcus invading the epicone could be included in *Gyrodinium*, while those species without sulcus intrusion on the epicone could be in *Gymnodinium*; 2) *Gyrodinium* could be emended to include those species with greater than 1/3rd cingulum displacement(*Gymnodinium* would be less than 1/3rd) and 3) combine all species under *Gymnodinium*. Because of possible synonymy between *Aureodinium* and *Woloszynskia* with *Gymnodinium*, no particular emendation is recommended at this time.

Studies on *Peridinium*, a major armored dinoflagellate genus, have recently indicated homonymy. The genus is characterized by the plate formula: 4', 2-3*a*, 7'', 4-6c, 4s, 5''' and 2''''. Within the last decade new separating characters have been recognized and employed, e.g., the number of cingular and sulcal plates and the presence or absence of an apical pore. This distinction allows *Peridinium* to be divided into three genera: *Peridinium* (freshwater, e.g., *P. cinctum*) *Archaeperidinium* (marine, e.g., *A. minutum*) and *Scrippsiella* (marine, e.g., *S. sweeneyii*) according to Loeblich III (1968a) who briefly mentioned the problem in *Peridinium* homonymy. However, Balech (personal communication) points out that *Archaeperidinium* is not the oldest available name to consider. *Protoperidinium* Bergh (type: *P. pellucidum*) is older and better suited (3 anterior intercalaries) to represent the marine *Peridinium*. But as Dr. Balech also mentioned, better knowledge of the freshwater *Peridinium* is needed before any "split" in *Peridinium* is attempted.

Therefore, almost all known species must be re-evaluated, using additional criteria. Plate analyses are now critical, e.g., the number of cingular plates. On the other hand, the number of cingular plates may not be diagnostic. *Scrippsiella faeroense* and *Ensiculifera mexicana* are similar to *Peridinium trochoideum* except in total number of cingular plates and the shape of certain sulcal plates. Clonal culture work in various media may show that cingular plate number is a variable, making separation on this basis alone inaccurate. In addition, Wall and Dale (1968c) further question the reliability of cingular plate tabulations. They suggest that resting spore characterization is more diagnostic and serves as a more accurate basis for postulated affinities in this diverse group. Wall and Dale also point out that botanically the fossil genus *Calciodinellum* would have priority over *Scrippsiella* thus compounding the existing problems.

Our Species Account presents all marine Peridinium-like forms (4', 2-3*a*, 7'', 5''' and 2'''') as *Peridinium*, awaiting further clarification.

Pyrophacus, a minor armored genus, also presents plate tabulation problems. Steidinger and Davis (1967) suggested a new designation – Coupling Antapical Plate (CAP) to help distinguish antapical plates from posterior intercalary plates. Normally, *P. horologium* and *P. horologium* var. *steinii* can easily be tabulated; however, an ecoform found in 1966 presented problems created by excessive plates. Now another ecoform has been encountered (Safety Harbor, Florida, 12 September 1969) with more plates than any known dinoflagellate which we designated as *Pyrophacus* Form B_2. One specimen measuring 100 μ in width had 57 epithecal plates and 56 hypothecal plates. There were 27 anterior intercalaries in two series. The CAP designation used by Steidinger and Davis (1967) is of no value in this form. It appears that most of the additional plates are formed from the division of postcingulars, precingulars, antapicals and apicals. From these data it may be speculated that *Pyrophacus* is monotypic with only *P. horologium*. The variety *P. horologium* var. *steinii* and Forms B_1 and B_2 are possibly only ecoforms of the species. The division of existing plates produces a higher surface area/volume ratio and may aid in flotation. Such plate configurations may arise because of low salinities as mentioned by Steidinger (1968). The salinity of the Safety Harbor samples ranged from 16.15 to 16.95 °/°°.

Abé (1967b) and Balech (1967b) combined *Phalacroma* with *Dinophysis*. This emendation was not followed in this paper. It is our experience that *Phalacroma* can be distinguished from *Dinophysis* by the direction of the cingular lists and the height of the epitheca. However, these distinctions are based on a limited number of representatives while Abé and Balech's decision was based on many species.

Other problem genera are covered in the generic description section and need no further discourse. However, there are several genera or species that may prove to be life stages of yet another genus. For example, one of the life stages of *Kofoidinium* could easily be mistaken for a new genus.

Problems in identification often arise with immature specimens. Most characters are based on mature individuals without consideration of developmental sequences. For example, species of *Gonyaulax* may encyst and later excyst if conditions are favorable. In *G. polygramma* the excysted cell is not heavily thecate and is without armor. After excystment the cell wall is divided into plates (marked by suture lines), then poroids are formed followed by striations. Since identification depends on the presence of striations, recognition of this species prior to their development is difficult. Another example is the genus *Ceratium*. Identification within this genus depends on the length, curvature and direction of antapical horns. Therefore identification of specimens with incompletely developed or damaged horns is difficult. To avoid this problem and to delineate interspecific variation, Yarranton (1967) used numerical criteria: 1) the orientation of the horn in relation to the cingulum plane, 2) the initial rate of curvature and 3) the rate of change of curvature. Yarranton worked with four species of the subgenus *Euceratium*, but speculated that his methods would apply to other species in the same subgenus.

Further confusion may arise in certain genera which have polymorphic forms. In our clonal cultures of *Ceratium trichoceros* and *C. tripos* var. *atlanticum* (unpublished data), dimorphic forms were observed. The parental form resembled a typical cell while the hypotheca of the daughter product was not typical of *Euceratium* but rather *Ceratium* (=*Biceratium*). If the daughter product were encountered in the plankton, it would be identified as an aberrant of *C. lineatum* or a similar form, perhaps even reported as a new species. Von Stosch (1964) suggested that this type of dimorphism may be sexual and the products perhaps gametes. However, fusion of "gametes" has never been observed.

SPECIES ACCOUNT

191 species and varieties were identified along with 41 unidentified taxa designated by letters. The following account is an ecological summary for those taxa observed and it presents horizontal distribution, seasonality, concentrations, salinity and temperature ranges and for those species measured, size ranges. OSR is observed salinity range, OTR is observed temperature range, OCR is observed count range. There were 504 live samples (collected with a Van Dorn water sampler) analyzed and 41 preserved tow samples. The sampling ranged over a period of 28 months. Rare indicates ⟨1% frequency of occurrence (based on live material), infrequent is only slightly higher. Most species were rare or infrequent. Supplemental data are provided in the appendices. Pertinent, morphological observations are mentioned. In addition, each species is forwarded by selected references, most of which are major works that should be available through a university or marine research facility. 148 of the 232 taxa were photographed. In the species account seasons are delineated as follows: Fall = September, October, November. Winter = December, January, February. Spring = March, April, May. Summer = June, July, August. Unless otherwise stated "Stations" refers to Red Tide Stations F, G, H, N, O, P.

Actiniscus pentasterias (Ehrenberg) Ehrenberg (Figures 1a, 1b).

Bursa (1969). Observed from Station N, surface, November 1966. Similiar forms encountered from Estero Pier in the following February. Occurred in ⟨1% of live samples. OS: 35.87. OT: 25.5 OC: ⟨100/liter.

Amphidinium carteri Hulburt (Figures 2a, 2b)

Hulburt (1957); Dodge and Crawford (1968). Rare, occurred in December 1965 and March 1966 at inshore stations. OSR 34.83 – 35.35. OTR: 19.5 – 28.0. OCR: ⟨100 – 167/liter.

Amphidinium crassum Lohmann

Kofoid and Swezy (1921); Lebour (1925). Occurred at middle and inshore stations at various depths during the first half of the study. OSR: 32.63 – 36.21. OTR: 17.0 – 31.5. OCR: ⟨100/liter – 5000/liter.

Amphidinium cucurbita Kofoid and Swezy (Figure 3)

Kofoid and Swezy (1921). Observed from Station N, middepth, April 1966 and Station E, surface, November 1967. OSR: 36.23 – 36.29. OTR: 20.0 – 24.5. OC: ⟨100/liter.

Amphidinium pelagicum Lebour

Lebour (1925). Observed only once from Station O, middepth, March 1966. OS: 35.35. OT: 24.5. OC: ⟨100/liter.

Amphidinium scissum Kofoid and Swezy (Figure 4)

Kofoid and Swezy (1921). Observed only once from Station N, surface, February 1967. OS: 36.19. OT: 18.5. OC: ⟨100/liter.

Amphidinium spp.

May include as many as five species.

Amphisolenia bidentata Schroder (Figures 5a – 5c)

Kofoid and Skogsberg (1928); Abé (1967c). Recorded in live material from Station E, July 1966 and Station M, May 1967. Occurred in ⟨1% of live samples. Supplemental tow data revealed its presence in summer and winter from various stations, most frequent from middle and offshore stations. Observed cell length, 783-885μ; body width, 10-31μ. OSR: 36.23 – 36.26. OTR: 25.0 – 26.5. OC: ⟨100/liter.

Amphisolenia bifurcata Murray and Whiting (Figures 6a – 6c)

Kofoid and Skogsberg (1928). Tow material in November and July 1966, June 1967.

Amphisolenia rectangulata Kofoid

Kofoid and Skogsberg (1928); Abé (1967c). Tow material from Station F, January 1966.

Amphisolenia B

Tow material from Station F, November 1967.

Amphisolenia C

Tow material from Station F, November 1967.

Amphisolenia spp.

Probably includes aberrants of the above species.

Blepharocysta compressa Gaarder? (Figure 8)

Gaarder (1954). Rare, found only in five samples from middle and offshore stations in March, October and November, 1967. This identification is questioned and the organism may be a new *Blepharocysta*. OSR: 35.68 – 36.33. OTR: 20.5 – 25.5. OC: ⟨100/liter.

Blepharocysta paulensii Schiller?

Schiller (1937): Balech (1963). Dubious identification, could have been forms of *B. splendor-maris*. *Blepharocysta* is a difficult group and little is known regarding variation. Total plate tabulation was not achieved. Rare, each record at a different station, including Station M. OSR: 34.68 – 36.50. OTR: 19.0 – 27.5 OC: ⟨100/liter.

Blepharocysta splendor-maris Ehrenberg (Figures 9a, 9b)

Balech (1963); Abé (1966). Occurred at all stations, most frequent in surface and middepth samples. Infrequent at inshore stations. Also observed from Stations E and M. Occurred in 19.6% of live samples. OSR: 32.82 – 36.55. OTR: 17.5 – 31.0. OCR: ⟨100 – 667/liter.

Blepharocysta A

Rare, possibly aberrant form of *B. spendor-maris.* OSR: 36.19 – 36.26. OTR. 22.5 – 24.5.OC : ⟨100/liter.

Blepharocysta B

Rare, possibly aberrant form of *B. splendor-maris*. Observed from Station O, September 1965; Station N, August 1967. OSR: 35.68 – 36.06. OTR: 25.0 – 29.7. OC:⟨100/liter.

Blepharocysta spp.

This category probably includes *B. splendor-maris* and other known species.

Ceratium belone Cleve (Figure 10)

Graham and Bronikovsky (1944). Recorded in live material from Station M, April 1966 and in tow material from Station F, November 1966 and Stations H and N, January 1967. OS: 36.35. OT: 20.0.

Ceratium bigelowii Kofoid (Figures 11a, 11b)

Graham and Broniskovsky (1944). Tow material from Station N, July 1966.

Ceratium bucephalum (Cleve) Cleve

Schiller (1937). Sournia (1967b) has recently reclassified this organism as *C. arietinum* var. *bucephalum*. Tow material from Station F, July 1966.

Ceratium buceros f. *tenue* (Ostenfeld and Schmidt) Schiller (Figure 12)

Schiller (1937). Possibly includes a few *C. buceros* f. *molle*. Recently, Sournia (1967b) reclassified this organism under a variety of *C. horridum.* Sporadic, infrequent more evident in spring months at middle and offshore stations. Also occurred at Station M, April 1967. OSR: 35.39 – 36.59. OTR: 18.5 – 28.5. OCR: ⟨100 – 167/liter.

Ceratium candelabrum var. *depressum* (Pouchet) Jorgensen (Figure 153)

Schiller (1937); Sournia (1967b). This variety is often considered within the specific variation (Graham and Bronikovsky, 1944). Recorded once in live material, Station E. May 1966 and once in tow material at Station O, June 1967. OS: 35.80. OT: 23.5.

Ceratium carriense Gourret (Figures 13a, 13b)

Schiller (1937); Sournia (1967b). This species has often been confused with *C. massiliense* or considered synonymous (Graham and Bronikovsky, 1944). Found almost exclusively in tow material from all stations, January 1966 to November 1967. Found in live material at only five offshore samples including E. Observed cell length, 411-972 μ; body width, 61-92 μ. OSR: 35.61 – 36.41. OTR: 18.5 – 26.0. OC: ⟨100/liter.

Ceratium carriense var. *volans* (Cleve) Jörgensen (Figures 14a, 14b)

Jörgensen (1920); Schiller (1937). Found almost exclusively in tow material, all stations, more frequent in winter – spring. This variety was only detected in two live samples from offshore stations in May 1966. Observed cell length, 356 – 900 μ; body width, 56 – 148 μ. OSR: 36.28 – 36.33. OTR: 22.0 – 23.5. OC: ⟨100/liter.

Ceratium concilians Jörgensen (Figure 15)

Jörgensen (1920); Bohn (1933); Sournia (1967b). Recorded in live material from Station M, surface, March 1966.

Ceratium contortum (Gourret) Cleve (Figures 16a, 16b)

Schiller (1937); Sournia (1967b). Infrequent, found at middle and offshore stations, middepth to surface and Stations E and M. Live data would indicate more of a spring-early summer occurrence but supplemental tow data revealed winter occurrence as well. OSR: 35.39 – 36.52. OTR: 18.0 – 30.5. OCR: ⟨100 – 167/liter.

Ceratium contortum var. *karstenii* (Pavillard) Sournia (Figures 17a, 17b)

Sournia (1967b). Rare in live samples from middle and offshore stations, recorded once from Station M, June 1966; however, observed in tow material from all stations. In 1966 and 1967 encountered mostly in winter, spring and summer. Observed cell length, 479-581 μ; body width, 87-112 μ. OSR: 35.37 – 36.19. OTR: 22.5 – 25.5. OC: ⟨100/liter.

Ceratium contortum f. *subcontortum* (Schroder) Steemann Nielsen

Schiller (1937). Rare, observed in live material from Station F, February, 1967. OSR: 35.93 – 36.14. OT: 19.0. OC: ⟨100/liter.

Ceratium declinatum f. *normale* Jörgensen (Figure 18)

Schiller (1937); Sournia (1967b). Sporadic, infrequent at middle and offshore stations including Stations E and M. OSR: 35.92 – 36.36. OTR: 20.0 – 26.5. OC: ⟨100/liter.

Ceratium extensum (Gourret) Cleve (Figure 19)

Jörgensen (1920); Schiller (1937); Sournia (1967b). Infrequent in live material, fairly common in tow samples. Live material mostly in summer and winter from middle and offshore stations including E and M. Supplemental tow data indicates wider distribution (seasonally and geographically). Observed cell length, 682-1726 μ; body width, 24-32 μ. OSR: 34.08 – 36.53. OTR: 21.0 – 30.0. OCR: 100 – 167/liter.

Ceratium falcatum (Kofoid) Jörgensen

Jörgensen (1920). Live material observed during winter from middle and offshore stations. Tow data indicate presence in spring. OSR: 35.51 – 36.16. OTR: 18.0 – 19.0. OC: ⟨100/liter.

Ceratium furca (Ehrenberg) Claparede and Lachmann (Figures 20a, 20b)

Jörgensen (1920); Sournia (1967b). This identification does not recognize varieties and forms. Occurred almost all year at all stations at varying depths. Least frequent in fall and spring months. Observed cell length, 194-276 μ; body width 26-42 μ. Occurred in 34.1% of live samples. OSR: 24.44 – 36.53. OTR: 17.0 – 31.2. OCR: ⟨100 – 500 liter.

Ceratium fusus (Ehrenberg) Dujardin (Figures 21a, 21b)

Davis (1964). Encountered throughout the year from all stations at varying depths. Also observed from Stations E and M. Least frequent in fall months. Observed cell length appears to be longer in the spring-summer, 344-725 μ, than fall-winter, 204-683 μ; body width 17-36 μ. Occurred in 44.8% live samples. OSR: 24.44 – 36.52. OTR: 15.5 – 32.0. OCR: ⟨100 – 500/liter.

Ceratium gibberum var. *dispar* (Pouchet) Sournia (Figures 22a, 22b)

Jörgensen (1920); Sournia (1967b). Rare, in live material from Station O, June 1966, and Station E, April 1966; tow material from Station N, April 1966. OSR: 35.85 – 36.41. ORT: 19.5 – 27.5. OC: ⟨100/liter.

Ceratium hexacanthum Gourret (Figures 23a-23c)

Jörgensen (1920); Davis (1965); Sournia (1967b). The curvature of the horns is quite variable in this species. Limited occurrence (⟨2%), in live samples, including Station E, more frequent in fall months yet frequently observed in tow material during all seasons. One specimen in tow material resembled *C. hexacanthum* var. *reflexum*. Observed cell length, 204-745 μ; body width 71-128 μ. OSR: 35.52 – 36.55. OTR: 19.5 – 27.5. OC: ⟨100/liter.

Ceratium hircus Schröder (Figures 24a, 24b)

Schiller (1937). This organism has often been referred to as *C. furca* by Florida workers (Hutton, 1956; Dragovich, Kelly and Kelly, 1965); however, as can be seen in Figure 24a, the antapical horns are equal, the right being directed ventrally. The direction of the right horn

disagrees with the original description. The remarkable consistency of this species in natural populations warrants its separation from *C. furca*. Most frequently found at inshore stations throughout the sampling program (23%), however there are offshore records including Station E. This species is characteristic of local estuarine waters and blooms. Observed cell length, 179-219 μ; body width, 28-41 μ. OSR: 24.44 – 36.52. OTR: 14.0 – 32.0. OCR: ⟨100 – 1167/liter.

Ceratium horridum (Cleve) Gran?

Jörgensen (1920); Sournia (1967b). Approximates Sournia's Figure 94, p. 478. Infrequent in fall and winter, mostly at middle and offshore stations, including M. OSR: 34.68 – 36.40. OTR: 21.0 – 24.0. OC: ⟨100/liter.

Ceratium humile Jörgensen?

Schiller (1937). Rare, observed in live material from Station F, March 1967, and tow sample, Station O, July 1966. Occurred in ⟨1% of live samples. OS: 35.93. OT: 18.0. OC: ⟨100/liter.

Ceratium inflatum (Kofoid) Jörgensen (Figure 25)

Jorgensen (1920); Schiller (1937). Rare in live samples (fall and winter); however tow data indicates higher frequency throughout 1966. Found from all stations, including M. Observed cell length, 609-928 μ; body width, 23-36 μ. OSR: 35.52 – 36.22. OTR: 17.5 – 26.0. OC: ⟨100/liter.

Ceratium kofoidii Jörgensen (Figure 26)

Schillder (1937); Sournia (1967b). Rare, present in two live samples in winter of 1966 and 1967, Stations F and M. Tow material from Station O, April 1966. OSR: 35.51 – 36.40. OTR: 21.0 – 23.5. OCR: ⟨100-167/liter.

Ceratium lineatum (Ehrenberg) Cleve

Sournia (1967b). Sporadic, infrequent never abundant. Life cycle work may show that this species is a gametic stage of such species as *C. trichoceros* and *C. tripos*. Clonal cultures of these species have been dimorphic with one form resembling *C. lineatum*. OSR: 34.88 – 36.31. OTR: 17.0 – 30.0. OCR: ⟨100-167/liter.

Ceratium longirostrum Gourret (Figure 27)

Jörgensen (1920). Rare, recorded from Station F. middepth. April and June, 1966. Tow material from Station G, February 1966 and Station F. November 1967. OSR: 36.09 – 36.14. OTR: 19.5 – 26.0. OC: ⟨100/liter.

Ceratium lunula (Schimper *ex* Karsten) Jörgensen (Figure 28)

Sournia (1967b). Rare in live samples; tow data indicate occurrence from January 1966 – July 1967, primarily from middle and offshore stations, and Station M, April 1966. OSR: 34.70 – 36.21. OTR: 20.0 – 27.0. OC: ⟨100/liter.

Ceratium macroceros var. *gallicum* (Kofoid) Sournia (Figures 29a, 29b)

Jörgensen (1920); Schiller (1937); Sournia (1967b). Live material indicates occurrence at middle and offshore stations primarily in spring-summer; tow data extends the distribution and winter occurrence. Infrequent species. Also recorded from Station E, April 1966. OSR: 35.27 – 36.45. OTR: 17.0 – 30.5. OC: ⟨100/liter.

Ceratium massiliense (Gourret) Jörgensen (Figures 30a-30c)

Jörgensen (1920); Schiller (1937); Sournia (1967b). One of the more common and abundant forms, occurring at all stations at all depths, including Stations E and M. Less frequent in late summer-early fall. Occurred in 19.2% of live samples. Observed cell length, 251-798 μ; body width, 61-122 μ. OSR: 32.82 – 36.52. OTR: 14.0 – 30.5. OCR: ⟨100-167/liter.

Ceratium minutum Jörgensen

Jörgensen (1920). Sporadic, not as common as the related species *C. lineatum*. This species may

be a life cycle form of another species. Recorded from December 1965 to January 1967 at various stations including Station M. OSR: 32.63 – 36.31. OTR: 21.0 – 31.5. OCR: ⟨100-167/liter.

Ceratium pentagonum var. *tenerum* Jörgensen (Figure 31)

Jörgensen (1920); Sournia (1967b). Live material indicates a predominantly winter and fall occurrence at middle and offshore stations, including E and M. Tow data shows additional spring and summer occurrences. OSR: 34.01 – 36.45. OTR: 17.0 – 29.0. OCR: ⟨100-167/liter.

Ceratium pulchellum Schröder (Figure 32)

Jörgensen (1920); Sournia (1967b). Sournia considers this organism to be *C. tripos* var. *puchellum*. Tow material from Station N, July 1967.

Ceratium ranipes Cleve (Figure 33)

Sournia (1967b). Tow material from Station H, April 1967.

Ceratium schröteri Schröder (Figure 154)

Tow material from Station N, January 1966.

Ceratium semipulchellum (Peters) Steemann Nielsen

Schiller (1937); Sournia (1967b). Sournia considers this form to be a variety of *C. tripos*. Observed only from Station P, October (tow material) and November (live material) 1967. OS: 34.13. OT: 19.0. OC: ⟨100/liter.

Ceratium symmetricum var. *coarctatum* (Pavillard) Graham and Bronikovsky (Figure 34)

Schiller (1937); Sournia (1967b). Observed once from Station G, February 1967 and Station E, April 1966. OSR: 35.61 – 36.41. OTR: 18.5 – 19.5. OC: ⟨100/liter.

Ceratium teres Kofoid (Figures 35a, 35b)

Jörgensen (1920); Schiller (1937). Live material indicates offshore distribution, including E and M. Tow data shows inshore and middle station occurrences. OSR: 35.19 – 36.36. OTR: 20.0 – 28.5. OCR: ⟨100-333/liter.

Ceratium trichoceros (Ehrenberg) Kofoid (Figures 36a-36d)

Jörgensen (1920), Schiller (1937), Davis and Steidinger (1966); Sournia (1967b). Common, occurring throughout the sampling program at various depths, including Stations F and M. More common throughout 1967. Dominant species in tow material. Occurred in 38.4% live samples. Observed cell length. 108-593 μ; body width. 31-61 μ. OSR: 24.44 – 37.73. OTR: 160. – 31.5. OCR: ⟨100-333/liter.

Ceratium trichoceros var. *contrarium* (Gourret) Schiller

Sournia (1967b). The separation of this variety is often questionable. Rare in live material, sporadic at inshore to offshore stations including E and M. OSR: 35.87 – 36.38. OTR: 21.0 – 28.5. OC: ⟨100/liter.

Ceratium tripos var. *atlanticum* Ostenfeld (Figures 37a, 37b)

Jörgensen (1920); Schiller (1937); Sournia (1967b). Common and abundant, occurred at all stations at various depths throughout the sampling program. More frequent in 1967. More prevalent from inshore and middle stations, also occurred at Stations E and M. Occurred in 28.3% live samples. Observed cell length, 118-388 μ; body width, 66-102 μ. OSR: 24.44 – 37.73. OTR: 16.0 – 32.0. OCR: ⟨100-333/liter.

Ceratium tripos var. *ponticum* Jörgensen (Figures 38a, 38b)

Jörgensen (1920); Sournia (1967b). Possibly includes other varieties of *C. tripos*. Encountered most frequently in 1966 from all stations at various depths. OSR: 31.87 – 36.16. OTR: 17.5 – 31.0. OCR: ⟨100-167/liter.

Ceratium vultur Cleve (Figure 155)

Schiller (1937). Chain-forming species. Observed only in tow samples.

Ceratium vultur var. *sumatranum* (Karsten) Steemann Nielsen (Figure 39)
Schiller (1937). Tow material from offshore stations.

Ceratium spp.
Includes no more than five species, varieties, forms or aberrants.

Ceratocorys armata (Schütt) Kofoid (Figures 41a, 41b)
Schiller (1937); Graham and Bronikovsky (1944). Sporadic, primarily during 1966. Absent from inshore stations. Infrequent species. OSR: 35.52 – 36.52. OTR: 18-5 – 30.0. OC: ⟨100/liter.

Ceratocorys horrida Stein (Figures 42a – 42d)
Schiller (1937); Graham and Bronikovsky (1944). Primarily from middle and offshore stations, including E and M. One inshore record from tow data. More frequent from April 1966 to June 1967. Infrequent species. OSR: 35.66 – 36.45. OTR: 19.0 – 30.0. OC: ⟨100/liter.

Cochlodinium citron Kofoid and Swezy? (Figure 43)
Kofoid and Swezy (1921). Identification tentative. Infrequent, 1966-1967. OSR: 34.94 – 36.31. OTR: 19.5 – 30.0. OCR: ⟨100/167/liter.

Cochlodinium A (Figure 44)
Possibly a new species, usually observed in low to moderate concentrations. Noticeably absent from August to January, 1965, 1966. OSR: 34.23 – 36.41. OTR: 17.5 – 30.0. OCR: ⟨100-2667/liter.

Cochlodinium B (Figure 45)
Identification incomplete because of the scarcity of specimens. Observed only twice from Stations N and O, November 1967. OSR: 35.84 – 36.22. OTR: 21.0 – 21.5. OC: ⟨100/liter.

Cochlodinium spp.
Includes no more than five species.

Coolia monotis Meunier (Figure 82)
Schiller (1937); Balech (1956). Observed once from Station H, bottom November 1965. OS: 35.19. OT: 22.0. OC: ⟨100/liter.

Dinophysis caudata Saville-Kent
Kofoid and Skogsberg (1928); Bohm (1936); Abé (1967). The recognition of varieties and forms of this species varies among authors. Rare, observed only from inshore and middle stations in August 1965 and February and March 1966. OSR: 31.46 – 35.21. OTR: 16.0 – 30.2. OC: ⟨100/liter.

Dinophysis caudata var. *abbreviata* Jörgensen
Kofoid and Skogsberg (1928); Schiller (1937). Recorded once from Station O, September 1965. OS: 35.68. OT: 29.7. OC: ⟨100/liter.

Dinophysis caudata var. *acuminiformis* (Figure 46)
Kofoid and Skogsberg (1928). Infrequent, primarily in early spring through summer. Observed at various depths, never in large concentrations. Primarily a neritic-estuarine form. OSR: 33.55 – 36.24. OTR: 18.0 – 31.5. OCR: ⟨100-167/liter.

Dinophysis caudata var. *diegensis* (Kofoid)
Schiller (1937). Recorded once from Station F. August 1966. OS: 36.55. OT: 24.0. OC: ⟨100/liter.

Dinophysis caudata var. *pedunculata* Schmidt (Figure 47)
Kofoid and Skogsberg (1928); Bohm (1936); Abé (1967). Common and abundant variety occurring from all stations at various depths including Stations E and M. Decreasing frequency

from inshore to offshore. Usually scarce or absent in December and June. Occurred in 27.4% live samples. Observed cell length, 56-92 μ; body width, 41-47 μ. OSR: 24.44 – 36.59. OTR: 17.0-32.0. OCR: ⟨100-1500/liter.

Dinophysis fortii Pavillard

Kofoid and Skogsberg (1928); Abé (1967). Recorded once from Station E, November 1967. OS: 36.29. OT: 24.5. OC: ⟨100/liter.

Dinophysis hastata Stein (Figure 48)

Kofoid and Skogsberg (1928); Abé (1967). Recorded from Stations F and O, mid-depth only, July and August 1966. Occurred in ⟨1% live samples. OSR: 35.85 – 36.21. OTR: 26.0 – 30.0. OC: ⟨100/liter.

Dinophysis ovum Schütt (Figure 49)

Kofoid and Skogsberg (1928); Abé (1967). Recorded in live material from offshore stations, October 1967. Tow material, June 1967. Occurred in ⟨1% live samples. OSR: 34.88 – 35.57. OTR: 25.0 – 26.0. OC: 167/liter.

Dinophysis caudata var. A

Recorded once from Station F, August 1967, and Estero Pier, November 1966. OS: 34.90. OTR: 23.5 – 35.5. OC: ⟨100/liter.

Dinophysis caudata var. B

It is suspected that this represents an inshore form of *D. caudata* var. *pedunculata*. Sporadic, almost exclusively at Stations H and P. Recorded at various depths. Infrequent. OSR: 31.10 – 37.17. OTR: 18.2 – 31.5. OCR: ⟨100-333/liter.

Dinophysis C (Figure 50)

Identification incomplete because of scarcity and fragility of specimens. Observed only from middle and offshore stations. Sporadic, primarily from late winter to early summer. Infrequent. OSR: 34.92 – 36.19. OTR: 17.0 – 26.5. OCR: ⟨100-167/liter.

Dinophysis spp.

Includes no more than five species, perhaps variants of the above species.

Diplopsalis lenticula Bergh (Figure 51)

Schiller (1937). Not as common as the form *asymmetrica*. Occurred more in late winter to early summer. Recorded from all stations including Station E, April 1966, most frequent from inshore and middle stations. OSR: 32.63 – 36.41. OTR: 16.0 – 30.5. OCR: ⟨100-500/liter.

Diplopsalis lenticula f. *asymmetrica* (Mangin) (Figure 52)

Schiller (1937). Common form occurring at all stations including Stations E and M. Recorded throughout the sampling program. Occurred in 32.7% live samples. OSR: 29.29 – 36.59. OTR: 17.0 – 32.0. OCR: ⟨100-833/liter.

Diplopsalis lenticula f. *minor* Paulsen (Figure 53)

Schiller (1937). Rare, sporadic, observed mostly in tow material. OSR: 36.09 – 36.38. OTR: 20.0 – 31.5. OC: ⟨100/liter.

Diplopsalis orbicularis (Paulsen)

Schiller (1937). Rare, recorded only twice, Stations G and P. OSR: 32.22 – 34.94. OTR: 29.0 – 29.5. OC: ⟨100/liter.

Diplopsalis rotundata (Lebour)

Schiller (1937); Balech (1964). Balech renamed this species *Oblea rotundata*. We believe the erection of this new genus may not be warranted because of similarities with *Diplopsalis*. Sporadic throughout the sampling program from all stations. More frequent in 1966. OSR: 33.39 – 36.55. OTR: 18.5 – 31.5. OCR: ⟨100-500/liter.

Diplopsalis spp.

Probably variants of the above species.

Dissodinium lunula (Schütt) Klebs *in* Pascher, Stage I (Figure 55a)

Schiller (1937). Observed from middle and offshore stations including Stations E and M. Observed more in winter months. Infrequent. OSR: 34.90 – 36.31. OTR: 17.5 – 30.5. OC: ⟨100/liter.

Dissodinium lunula (Schütt) Klebs *in* Pascher, Stage V (Figure 55b)

Recorded only once from Station M, in February, 1966. OS: 36.40. OT: 21.0. OC: ⟨100/liter.

Fragilidium sp. (Figure 56)

Balech (1959). Identification tentative, infrequently recorded from July 1966 to August 1967 at various depths. Not recorded from offshore stations. OSR: 33.94 – 36.41. OTR: 17.5 – 21.0. OCR: ⟨100-333/liter.

Glenodinium A

Dubious generic identity. Recorded from three samples in October 1965, May and August 1966. Rare. OSR: 33.61 – 35.82. OTR: 26.0 – 30.0. OCR: ⟨100-167/liter.

Glenodinium B (Figure 57)

Summer distribution indicated, August and September. OSR: 35.71 – 36.61. OTR: 30.0 – 30.5. OC: ⟨100/liter.

Glenodinium spp.

Could include up to 10 species, some of them no doubt *Peridinium* spp.

Gonyaulax acatenella Whedon and Kofoid

Whedon and Kofoid (1936); Prakash and Taylor (1966). Identification tentative. Tow material from Station G, July 1966.

Gonyaulax diacantha (Meunier) Schiller (Figures 58a, 58b)

Schiller (1937). Infrequently recorded from July 1966 to October 1967, occasionally in moderate numbers. Bloom species in local Florida bays. Not encountered from offshore stations. OSR: 34.11 – 36.50. OTR: 18.5 – 31.5. OCR: ⟨100-2333/liter.

Gonyaulax diegensis Kofoid (Figures 59a, 59b)

Kofoid (1911). Infrequent, not occurring at offshore stations. OSR: 34.01 – 36.14. OTR: 18.0 – 30.5. OC: ⟨100/liter.

Gonyaulax digitalis (Pouchet) Kofoid (Figures 60a, 60b)

Kofoid (1911). Infrequently observed from all stations at various depths. More frequent from inshore and middle stations. OSR: 31.87 – 36.55. OTR: 17.5 – 31.5. OCR: ⟨100-167/liter.

Gonyaulax fragilis (Schütt) Kofoid (Figures 61a-61c)

Kofoid (1911); Balech (1962). Recorded from all stations including Stations E and M. Infrequent from April 1966 to November 1967. Identification prior to April 1966 may have been only to genus. OSR: 31.87 – 36.52. OTR: 18.8 – 31.0. OCR: ⟨100-833/liter.

Gonyaulax hyalina Ostenfeld and Schmidt

Schiller (1937). Identification tentative. Recorded from Stations F and G, May and April 1966. OSR: 35.21 – 35.54. OTR: 19.0 – 19.5. OC: 167/liter.

Gonyaulax monilata Howell (Figures 62a, 62b)

Howell (1953). Toxic catenate dinoflagellate, capable of reaching massive concentrations. Infrequently observed primarily from inshore and middle stations. Bloomed at Estero Pier in August and September 1966. OSR: 27.83 – 36.40. OTR: 17.5 – 32.0. OCR: ⟨100-775,000/liter.

Gonyaulax polyedra Stein (Figure 63)

Kofoid (1911). Rare, reportedly toxic species. Occurring at middle and offshore stations, including E. OSR: 35.62 – 36.28. OTR: 17.5 – 30.0. OC: ⟨100/liter.

Gonyaulax polygramma Stein (Figures 64a – 64c)

Steidinger (1968). Common *Gonyaulax* species, occasionally encountered in moderate numbers, but capable of blooming in estuarine and neritic environs. Recorded from all stations, including Stations E and M, at various depths. Occurred in 24% live samples. Observed cell length: 35-66 μ; cell width: 26-56 μ. OSR: 30.49 – 36.50. OTR: 17.0 – 31.5. OCR: ⟨100-15,500/liter.

Gonyaulax scrippsae Kofoid

Kofoid (1911) and Schiller (1937). Infrequent, mainly occurring at middle and offshore stations. OSR: 34.03 – 37.17. OTR: 20.5 – 31.5. OCR: ⟨100-⟨1000/liter.

Gonyaulax spinifera (Claparede and Lachmann) Diesing

Kofoid (1911). Not as common as *G. digitalis* or *G. polygramma.* Sporadic, at all stations, recorded at various depths. More frequent from inshore and middle stations. It is thought by some workers that this species is indistinguishable from *G. digitalis* and perhaps a growth phase; however, from our samples it appears distinct. The cingular area is quite characteristic. In addition, cyst data (Wall, 1968a) indicates two distinct species. OSR: 32.32 – 37.17. OTR: 14.0 – 31.5. OCR: ⟨100-4000/liter.

Gonyaulax turbynei Murray and Whiting (Figures 65a, 65b)

Kofoid (1911); Steidinger (1968). Sporadic, infrequent. OSR: 34.49 – 36.00. OTR: 19.0 – 30.5. OCR: ⟨100-333/liter.

Gonyaulax E

May represent growth form of *G. diegensis*. Only recorded in early part of study, from Station P, August and September 1965. OSR: 24.44 – 35.09. OTR: 29.8 – 32.0. OCR: ⟨100-3 33/liter.

Gonyaulax sp. (catenate) (Figure 66)

Resembles *G. tamarensis* var. *excavata*. Tow material from Station G, July 1966.

Gonyaulax spp.

Probably ineludes variants of the above species.

Gymnodinium breve Davis (Figure 67)

Steidinger, Davis and Williams (1966); Dragovich (1967); Wilson (1967). Toxic species responsible for most of Florida's Red Tides. Fairly common in low-moderate numbers (below lethal concentrations). Recorded from all stations at various depths. Occurred throughout the program, except in August 1965 and February 1966. This species has distinguishable forms, two are represented here, the "butterfly" type (broad, little cingulum displacement) and the "CK" type (concave-convex, cingulum displaced up to 2X), both are contractile horizontally. Occurred in 26.6% live samples. CK form measurements 20-36 μ long. OSR: 27.64 – 36.55. OTR: 17.5 – 31.5. OCR: ⟨100-476,000/liter.

Gymnodinium coeruleum Dogiel (Figures 68a, 68b)

Kofoid and Swezy (1921). Large, green, blue, blue-green or pink pigmentation. Sporadic, not recognized prior to May 1966. Observed only twice from inshore stations. OSR: 34.95 – 36.53. OTR: 17.5 – 31.5. OCR: ⟨100-167/liter.

Gymnodinium incisum Kofoid and Swezy

Kofoid and Swezy (1921). Observed only once from Station P, middepth, April 1966. OS: 34.83. OT: 20.5. OC: 167/liter.

Gymnodinium splendens Lebour (Figures 69a – 69d)

Lebour (1925); Steidinger (1964). Common neritic species, recorded from all stations including M. Frequent bloom species in Florida bays. Occurred in 21.2% live samples. Observed cell length: 56-87 μ; body width, 42-61 μ. OSR: 24.44 – 37.17. OTR: 14.0 – 32.0. OCR: ⟨100-1883/liter.

Gymnodinium A

Identification incomplete because of scarcity and fragility of specimens. Recorded from Station G, November 1965 and Station O, December 1965, January 1966. OSR: 35.01 – 35.63. OTR: 18.5 – 23.5. OCR: ⟨100-167/liter.

Gymnodinium E (Figure 70)

Possibly represents a new species. Sporadic from May 1966 to November 1967. Not reported from offshore stations. Found at all depths, no apparent vertical stratification. Morphologically similar to *G. breve* but without concavity. OSR: 34.08 – 36.41. OTR: 17.5 – 32.0. OCR: ⟨100-833/liter.

Gymnodinium F

Identification incomplete because of scarcity and fragility of specimens. Encountered only once from Station F, bottom, August 1966. OS: 36.55. OT: 24.0. OC: ⟨100/liter.

Gymnodinium G

Identification incomplete because of scarcity and fragility of specimens. Observed only once, Station N, bottom, September 1966. OS: 36.40. OT: 25.0. OC: ⟨100/liter.

Gymnodinium H

Identification incomplete because of scarcity and fragility of specimens. Recorded twice at Station F, middepth, June and August, 1966. OSR: 36.19 – 36.23. OTR: 22.5 – 24.5. OC: ⟨100/liter.

Gymnodinium I (Figure 71)

This may be an aberrant of *G. coeruleum*. Infrequent, sporadic. Recorded primarily from middepth samples from June to November 1967. OSR: 35.01 – 36.26. OTR: 21.5 – 29.5. OC: ⟨100/liter.

Gymnodinium J (Figure 72)

Recorded from Station P, middepth and bottom, July 1967. OSR: 36.12 – 36.18. OT: 30.5. OC: ⟨100/liter.

Gymnodinium K

Identification incomplete because of scarcity and fragility of specimens. Recorded only once from Station F, April 1966. OS: 35.54. OT: 19.0. OC: 167/liter.

Gymnodinium/Glenodinium

Mixed grouping of small, thinly armored or unarmored species, sometimes dominant. Only recorded from August to September 1965 after which this taxon "*Gymnodinium/Glenodinium*" was abandoned and cells were recorded as *Gymnodinium* spp. unless thecae were detected.

Gymnodinium spp.

Major grouping, may have included some thinly armored *Glenodinium, Peridinium* species at times. Recorded in almost all samples as were *Gyrodinium* spp.

Gyrodinium caudatum Kofoid and Swezy

Kofoid and Swezy (1921). Recorded once from Station E, November 1967. OS: 36.29. OT: 24.5. OC: ⟨100/liter.

Gyrodinium falcatum Kofoid and Swezy (Figures 73a, 73b)

Kofoid and Swezy (1921). Observed from middle and offshore stations. Infrequent during late 1966 to early 1967. Large distinctive species, never abundant. OSR: 35.40 – 36.22. OTR: 18.5 – 28.5. OCR: ⟨100-167/liter.

Gyrodinium fissum Levander (Figure 75)

Kofoid and Swezy (1921); Kimball and Wood (1965). Observed at all depths with more frequency in surface samples. With the exception of two samples, occurred at inshore and middle stations and also recorded from Stations E and M. Sporadic occurrence in low to moderate numbers. Occasionally dominant, estuarine species. OSR: 24.44 – 36.41. OTR: 18.2 – 32.0. OCR: ⟨100-6333/liter.

Gyrodinium spirale (Bergh) Kofoid and Swezy

Kofoid and Swezy (1921). Recorded at all depths, more frequent in surface samples. Observed from all stations, more frequent from inshore and middle stations. OSR: 24.44 – 37.17. OTR: 18.0 – 32.0. OCR: ⟨100-333/liter.

Gyrodinium F (Figure 75)

Sporadic, occurred mainly during March 1966 to April 1967. We believe this is a form of *G. falcatum*, in addition their occurrence overlaps. OSR: 33.60 – 36.19. OTR: 18.5 – 30.0 OCR: ⟨100 – 5000/liter.

Gyrodinium G

Identification incomplete because of scarcity and fragility of specimens. Recorded from August to October 1965. Possibly grouped with *Gyrodinium* spp. in subsequent identifications. OSR: 31.42 – 36.21. OTR: 28.9 – 30.0. OCR: ⟨100-333/liter.

Gyrodinium H

Identification incomplete because of scarcity and fragility of specimens. Recorded once from Station O, middepth, June 1966. OS: 35.66. OT: 26.5. OC: ⟨100/liter.

Gyrodinium spp.

Mixed grouping, representing several (⟨10) species. Dominant throughout the sampling program.

Heteraulacus acuminatus (Ehrenberg) Diesing (Figures 76a-76f)

Schiller (1937); Graham and Bronikovsky (1944); Loeblich and Drugg (1968a, 1968b). Almost exclusively encountered from middle and offshore stations including Stations E and M. Occurred almost all year. Least represented in early fall of 1965, 1966 and summer 1967. Fairly common, never abundant. Occurred in 17.1% live samples. OSR: 30.49 – 36.55. OTR: 17.0 – 30.5. OCR: ⟨100 – 667/liter.

Heteraulacus sphaericum (Murray and Whiting) (Figure 77)

Schiller (1937); Graham and Bronikovsky (1944); Loeblich and Drugg (1968a, 1968b). Recorded from middle and offshore stations, including Station M. Primarily encountered April to July 1966, 1967. OSR: 35.74 – 36.55. OTR: 18.5 – 29.5. OCR: ⟨100-167/liter.

Katodinium glaucum (Lebour) Loeblich III

Lebour (1925). Common and abundant, occurring at all stations, recorded at all depths. Lowest frequency in early fall. Small unarmored forms, difficult to detect. Occurred in 38.5% live samples. OSR: 27.64 – 37.17. OTR: 15.5 – 37.5. OCR: ⟨100-10,000/liter.

Katodinium rotundatum (Lohmann) Loeblich III

Schiller (1933); Loeblich III (1965). Occasionally blooms in Florida's west coast estuaries. Observed from Stations O and N in November 1965, high concentrations. OSR: 34.65 – 35.84. OTR: 23.0 – 23.5. OCR: 5,000/liter.

Katodinium spp.

Probably includes *K. rotundatum*, occasionally in large numbers from Station P, middepth, otherwise scattered occurrence.

Kofoidinium pavillardii Cachon and Cachon (Figures 78a, 78b)

Kofoid and Swezy (1921); Cachon and Cachon (1967c). Several specimens of *K. splendens* were unfortunately included under this species. Two life forms of this species were encountered from Station O, September and October 1967 and also from Station M. Species observed from Stations G, O, and N at various depths, primarily in spring and fall months. OSR: 35.34 – 36.30. OTR: 21.0 – 29.0. OC: ⟨100/liter.

Nematodinium spp.

Recorded only twice, Station P, September 1965 and Station H, February 1966, middepth and bottom.

Ornithocercus magnificus Stein (Figures 79a, 79b)

Norris (1969a). Rare, encountered from middle and offshore stations and E. OSR: 33.18 – 36.31. OTR: 21.0 – 29.3. OC: ⟨100/liter.

Ornithocercus steinii Schütt (Figure 80)

Abé (1967) Rare, recorded from Station E, April 1966 and Station M, June 1966, August 1967. OSR: 35.97-36.45. OTR: 19.5-29.0. OC: ⟨100/liter.

Ornithocercus thumii (Schmidt) Kofoid and Skogsberg (Figure 81)

Abé (1967c). Tow material, Station N, January 1967 and Station O, June 1967.

Oxyrrhis marina Dujardin (Figure 83)

Kofoid and Swezy (1921). Occasionally dominant. Primarily from inshore and middle stations during late 1965 to early 1966. OSR: 33.05 – 36.55. OTR: 17.0 – 30.0. OCR: ⟨100-10,000/liter.

Oxyrrhis sp.

Rare, probably forms of *O. marina*

Oxytoxum elegans Pavillard (Figure 84)

Schiller (1937). Observed from Station F, February 1967, and Station N, June 1967. OSR: 36.14 – 36.40. OTR: 19.0 – 26.5. OC: ⟨100/liter.

Oxytoxum gigas Kofoid (Figures 85a-85c)

Kofoid (1907a); Schiller (1937). Recorded primarily from offshore stations (one exception) including Station E. Infrequent and sporadic. OSR: 35.85 – 36.52. OTR: 18.0 – 26.0. OC: ⟨100/liter.

Oxtoxum milneri Murray and Whiting (Figure 86)

Schiller (1937). Observed only twice, Station N, July 1966, and Station G, August 1966. OSR: 36.04 – 36.31. OTR: 26.0 – 30.5. OC: ⟨100/liter.

Oxytoxum scolopax Stein (Figure 87)

Schiller (1937). Rare, observed from middle and offshore stations (middepth and bottom) including Stations E and M. OSR: 35.57 – 36.36. OTR: 20.5 – 27.5. OC: ⟨100/liter.

Oxytoxum tesselatum (Stein) Schütt (Figure 88)

Schiller (1937). Observed only once, Station F, middepth, July 1966. OS: 36.09. OT: 26.0. OC: ⟨100/liter.

Oxytoxum A

Recorded only from Station O, all depths, August 1965. OSR: 33.18 – 35.71. OT: 29.3. OC: ⟨100/liter.

Oxytoxum sp. (Figure 89)

Recorded once from Station E in November 1967. OS: 36.29. OT: 24.5. OC: ⟨100/liter.

Oxytoxum spp.

Only two recordings which may have been aberrants.

Peridinium abei Paulsen (Figures 90a-90c)

Abé (1936). Infrequent at inshore and middle stations in summer months. Occurred in ⟨2% live samples. OSR: 33.94 – 36.38. OTR: 29.8 – 32.0. OCR: ⟨100-167/liter.

Peridinium biconicum Dangeard (Figures 91a, 91b)

Abé (1936). Infrequent, absent in winter-spring months. Higher frequency in middepth and bottom samples. OSR: 34.01 – 36.22. OTR: 18.5 – 31.5. OC: ⟨100/liter.

Peridinium breve Paulsen

Schiller (1937). Sporadic, highest frequency in summer through early fall, 1967. Recorded from all stations except Station O. OSR: 33.05 – 36.50. OTR: 18.2 – 31.5. OCR: ⟨100-2,000/liter.

Peridinium brochii Kofoid and Swezy (Figure 92)

Schiller (1937); Balech (1951). Similar to *P. divergens* but with thinner theca and less angular outline. Sporadic, never abundant. Recorded from all stations including E and M. OSR: 31.29 – 36.35. OTR: 17.5 – 30.5. OCR: ⟨100-333/liter.

?Peridinium brochii var. *inflatum* (Okamna) Schiller

Schiller (1937). Identification tentative. An inflated, fragile form. Rare, only found in summer months. OSR: 33.60 – 36.28. OTR: 23.0 – 30.0. OC: ⟨100/liter.

Peridinium claudicans Paulsen (Figures 93a, 93b)

Lebour (1925); Schiller (1937); Balech (1951). Live material indicates inshore and middle station distribution, while one tow sample was positive for Station F. Encountered at varying depths. Primarily in summer and early fall with a few winter-spring occurrences. Most specimens were similar to Lebour's (1925) illustration while a few inflated forms identified well with Dangeard's figure. No doubt some identified as *P. claudicans* were *P. latidorsale* Balech. OSR: 32.63 – 37.17. OTR: 18.0 – 32.0. OCR: ⟨100-167/liter.

Peridinium claudicans/oblongum

The intergradations between *P. claudicans* and *P. oblongum* appear to be numerous. Such forms observed in June and July 1967 from inshore and middle stations. OSR: 36.02 – 36.38. OTR: 28.5 – 31.5. OCR: ⟨100-333/liter.

Peridinium conicoides Paulsen

Schiller (1937). Observed in three samples, Station O, January 1967, Station G, March 1967 and Station H, May 1967. OSR: 35.50 – 36.52. OTR: 18.0 – 28.5. OC: ⟨100/liter.

Peridinium conicum (Grand) Ostenfeld and Schmidt (Figures 94a, 94b)

Abé (1936); Schiller (1937). Sporadic, infrequent in spring and fall months. Found at varying depths. Highest frequency from inshore and middle stations. OSR: 32.63 – 37.17. OTR: 16.0 – 31.5. OCR: ⟨100-167/liter.

Peridinium crassipes Kofoid (Figures 95a, 95b)

Abé (1936); Schiller (1937); Graham (1942). Fairly common large species, never abundant. Found from all stations, including Stations E and M. Highest frequency from inshore and middle stations during 1966, 1967. Occurred in 25.8% live samples. Observed cell length, 97-122 μ; body width, 97-117 μ. OSR: 31.42 – 37.17. OTR: 17.5 – 32.0. OCR: ⟨100-333/liter.

Peridinium curvipes Ostenfeld?

Schiller (1937). Identification tentative. Recorded once, Station N, bottom, August 1966. OS: 36.40. OT: 25.0. OC: 167/liter.

Peridinium depressum Bailey (Figures 96a, 96b)

Graham (1942). Common in tow material. Highest frequency from inshore and middle stations, yet occurred at all stations including Station E. Distributed throughout the water column. OSR: 32.63 – 37.17. OTR: 14.0 – 31.2. OCR: ⟨100-333/liter.

Peridinium divergens Ehrenberg (Figures 98a, 98b)

Schiller (1937). Highest frequency from late winter through summer. Species similar to *P. brochii.* Recorded from all stations, highest frequency from inshore and middle stations at various depths, and Stations E and M. OSR: 32.82 – 37.76. OTR: 17.5 – 30.5. OCR: ⟨100-167/liter.

Peridinium elegans Cleve (Figure 99)

Schiller (1937). Live material, including Stations E and M, shows spring and summer occurrence (1967). Tow data reveals presence in fall. Infrequent. OSR: 35.07 – 36.41. OTR: 19.5 – 25.5. OC: ⟨100/liter.

Peridinium elegans var. *granulata* (Karsten) (Figures 100a, 100b)

Schiller (1937). Tow material only, spring, summer and fall. Similar distribution and occurrence as the species.

Peridinium excentricum Paulsen (Figures 101a, 101b)

Abe' (1936) Schiller (1937); Balech (1951). Infrequent, almost exclusive at inshore stations, not abundant. This species has, however, been observed in high concentrations in Florida's estuarine waters. OSR: 32.63 – 36.50. OTR: 27.5 – 32.0. OCR: ⟨100-500/liter.

Peridinium fatulipes Kofoid (Figures 102a, 102b)

Kofoid (1907a); Schiller (1937). Tow material, Station O, June 1967.

Peridinium globulus Stein

Schiller (1937). Sporadic, recorded at various depths, all stations including Station M. Absent in July 1966 and 1967. OSR: 32.82 – 36.52. OTR: 17.5 – 30.5. OCR: ⟨100-333/liter.

Peridinium globulus var. *ovatum* (Pouchet) Schiller

Schiller (1937). Infrequent, encountered less than the species. Observed primarily through early summer in 1967. Recorded from all stations. OSR: 34.03 – 36.40. OTR: 17.0 – 29.0. OCR: ⟨100-167/liter.

Peridinium globulus var. *quarnerense* (Schröder) (Figure 103)

Schiller (1937). Sporadic, the rarest variety of this species. OSR: 34.52 – 36.36. OTR: 24.0 – 29.5. OCR: ⟨100-167/liter.

Peridinium grande Kofoid (Figure 104)

Kofoid (1907a); Schiller (1937). Tow material only, Stations F and P, July 1966, Station P, October 1966 and Station O, June 1967.

?Peridinium granii Ostenfeld

Schiller (1937). Identification tentative. Infrequent, recorded in only five samples from live material, inshore and offshore stations. Also recorded from Stations E and M. OSR: 34.46 – 36.30. OTR: 20.0 – 29.0. OCR: ⟨100-167/liter.

Peridinium leonis Pavillard? (Figure 105)

Schiller (1937). Identification tentative. Sporadic, infrequent. More common in 1966. OSR: 33.94 – 36.28. OTR: 20.5 – 26.0. OC: ⟨100/liter.

Peridinium leonis f. *matzenaueri* Schiller

Schiller (1937). Rare, encountered from Station P, bottom, October and November 1966. OSR: 34.51 – 34.78. OTR: 23.0 – 27.5. OC: ⟨100/liter.

Peridinium longipes Karsten (Figure 97)

Schiller (1937). Recorded from live material, Station E, April 1966 and tow material, Station O, June 1967. OS: 36.41. OT: 19.50.

Peridinium minutum Kofoid

Schiller (1937); Balech (1964c). Rare, recorded in four samples from Stations O and P, August and October 1967. Tow material from Station N, April 1966. OSR: 34.96 – 36.16. OTR: 25.0 – 30.0. OCR: ⟨100-667/liter)

Peridinium novascotiense Gran and Braarud?

Schiller (1937). Identification tentative. Recorded only from Station G, middepth, May 1966. OS: 35.61. OT: 24.5. OC: ⟨100/liter.

Peridinium nipponicum Abé

Abé (1936); Schiller (1937). Fairly common but never abundant. Sporadic, recorded at varying depths during 1966-1967. Also recorded from Stations E and M. OSR: 31.29 – 36.45. OTR: 17.0 – 31.5. OCR: ⟨100-333/liter.

Peridinium oblongum (Aurivillius) Cleve (Figures 107a-107d)

Abé (1936); Schiller (1937). Common, well represented in live and tow samples. Recorded almost exclusively at inshore and middle stations, most frequent during January through July 1966, 1967. OSR: 31.46 – 36.59. OTR: 17.0 – 32.0. OCR: ⟨100-167/liter.

Peridinium ovum (Schiller) (Figure 108)

Schiller (1937). Recorded from Stations O and P, April-May 1966. Tow material from Station N, July 1966. Never abundant. OSR: 34.75 – 35.39. OTR: 20.0 – 26.0. OCR: ⟨100-167/liter.

Peridinium pallidum Ostenfeld (Figure 109)

Schiller (1937). Rare, observed in only two samples, Stations H and N. OSR: 34.97 – 36.19. OTR: 18.5 – 27.0. OC: ⟨100/liter.

Peridinium pallidum var. *schilleri* (Paulsen) Schiller? (Figure 110)

Schiller (1937). Identification tentative. Recorded once from Station N, middepth, February 1967. OS: 36.19. OT: 18.5. OC: 167/liter.

Peridinium pellucidum (Bergh) Schütt (Figure 111)

Abé (1936); Schiller (1937); Balech (1964c). Fairly common, occurring at all stations at varying depths but least frequent at Stations O and G. OSR: 31.29 – 36.50. OTR: 17.0 – 31.5. OCR: ⟨100-667/liter.

Peridinium pentagonum Gran (Figures 112a, 112b)

Abé (1936); Schiller (1937). Large species, primarily fall through winter occurrence at inshore and middle stations. Never abundant. OSR: 24.44 – 36.16. OTR: 16.0 – 33.5. OCR: ⟨100-167/liter.

Peridinium pentagonum var. *latissimum* (Kofoid) Schiller (Figure 113)

Schiller (1937). Infrequent, fall through winter occurrence at inshore and middle stations. Observed mostly in 1965-1966. OSR: 33.99 – 35.97. OTR: 16.0 – 29.0. OC: ⟨100/liter.

Peridinium pyriforme Paulsen?

Schiller (1937). Identification incomplete because of scarcity and fragility of specimens. Recorded once from Station N, surface, March 1966. OS: 35.85. OT: 20.5. OC: ⟨100/liter.

Peridinium quinquecorne Abé

Abé (1936). Tow material from Station H, January 1966. Common, small, local estuarine species.

Peridinium solidicorne Mangin?

Schiller (1937). Identification incomplete because of scarcity and fragility of specimens. Tow material from Station G, July 1966.

Peridinium spiniferum Schiller (Figures 114a, 114b)

Schiller (1937). Observed from Stations O and P, November 1967. OSR: 34.20 – 35.81. OTR: 19.0 – 21.0. OCR: ⟨100-167/liter.

Peridinium steinii Jörgensen

Kofoid (1909) Schiller (1937). Tow material from Station O, June 1967.

Peridinium subinerme Paulsen (Figure 115)

Schiller (1937). Fairly common, sporadic primarily December through July at varying depths, never abundant. OSR: 31.29 – 36.50. OTR: 17.0 – 31.5. OCR: ⟨100-333/liter.

Peridinium subinerme var. *punctulatum* (Paulsen) Schiller (Figure 116)

Schiller (1937). Not as frequent as the species but with a similar distribution. More frequent in 1966. OSR: 33.55 – 36.28. OTR: 18.0 – 32.0. OCR: ⟨100-333/liter.

Peridinium trochoideum (Stein) Lemmermann (Figures 117a, 117b)

Schiller (1937). Our records may represent a heterogeneous group of several species perhaps even genera. This taxon could have included *Scrippsiella* spp. and *Ensiculifera*. Bloom species, recorded in varying concentrations from all stations, all depths. Absent in August 1965 and February 1967. Common local estuarine species. Also observed from Stations E and M. Occurred in 21.4% live samples. OSR: 33.14 – 37.17. OTR: 17.5 – 31.5. OCR: ⟨100-3,000/liter.

Peridinium tuba Schiller? (Figure 118)

Schiller (1937). Identification in doubt. Observed only from Station O, surface, May 1967 and Station M, May 1966. OSR: 35.92 – 36.16. OTR: 24.5 – 25.5. OC: ⟨100/liter.

Peridinium venustum Matzenauer (Figures 119a, 119b)

Schiller (1937). Infrequent, difficult to differentiate at times because of apparent intergradations between this species and *P. oblongum*. More evident in July and August 1966-1967, also recorded for fall 1966, spring 1967. OSR: 31.29 – 36.52. OTR: 19.7 – 31.5. OCR: ⟨100-167/liter.

Peridinium wiesneri Schiller?

Schiller (1937). Identification tentative. Observed from Station P, April 1966 and Station G, May 1967. OSR: 34.83 – 36.14. OTR: 20.5 – 26.5. OC: ⟨100/liter.

Peridinium D

Form similar to *P. excavatum* Martin (1929). Sporadic. Highest frequency from fall to spring, 1966. Occurred primarily at inshore and middle stations. OSR: 32.20 – 37.17. OTR: 17.5 – 32.0. OCR: ⟨100-167/liter.

Peridinium L

Identification incomplete because of scarcity and fragility of specimens. Recorded only from Station O, surface, August 1966. OS: 35.82. OT: 30.0. OC: 167/liter.

Peridinium N

Identification incomplete because of scarcity and fragility of specimens. Recorded only from Station G, bottom, January 1966. OS: 35.56. OT: 20.5. OC: ⟨100/liter.

Peridinium O

Identification incomplete because of scarcity and fragility of specimens. Recorded only from Station G, middepth, September 1965. OS: 36.21. OT: 30.0. OC: ⟨100/liter.

Peridinium P

Identification incomplete because of scarcity and fragility of specimens. Recorded only from Station H, surface, November 1967. OS: 33.55. OT: 24.5. OC: ⟨100/liter.

Peridinium T

Possibly represents a new species. Recorded at least once from all stations, October 1965 through February 1966. Never abundant. OSR: 32.82 – 36.14. OTR: 17.0 – 26.0. OCR: ⟨100-167/liter.

Peridinium U

Identification incomplete because of scarcity and fragility of specimens. Recorded only from Station N, bottom, September 1965. OS: 30.49. OT: 22.2. OC: 167/liter.

Peridinium spp.

Includes no more than ten species not identified or designated.

Phalacroma apicatum Kofoid and Skogsberg (Figure 120)

Kofoid and Skogsberg (1928); Abé (1967b). Recorded only once from Station M, October 1967. OS: 36.29. OT: 26.5. OC: ⟨100/liter.

Phalacroma argus Stein (Figure 121)

Schiller (1937); Abé (1967b). Sporadic, infrequent at middle and offshore stations. Not recorded in winter. Also reported from Stations E and M. OSR: 35.18 – 36.41. OTR: 18.5 – 30.5. OCR: ⟨100-167/liter.

Phalacroma cuneus Schütt (Figure 122)

Kofoid and Skogsberg (1928); Balech (1962); Abé (1967b). Recorded in live material from Station E, April 1966. OS: 36.41. OT: 19.5.

Phalacroma mitra Schütt

Kofoid and Skogsberg (1928); Abé (1967b). Recorded only from Station N, middepth, August 1965 and Station E, April 1966. OSR: 34.44 – 36.41. OTR: 19.5 – 28.7. OC: ⟨100/liter.

Phalacroma rapa Stein (Figure 123)

Kofoid and Skogsberg (1928) and Abé (1967b). Rare, recorded in only four middepth samples, offshore stations (May 1966, 1967 and June 1966). Tow material from Station G, April 1967. OSR: 36.02 – 36.55. OTR: 22.0 – 24.5. OC: ⟨100/liter.

Phalacroma rotundatum (Claparede and Lachmann) Kofoid and Michener (Figure 124)

Kofoid and Skogsberg (1928); Abé (1967b). Infrequent, winter through spring, primarily surface samples, middle and offshore, also recorded from Station E, November 1967. OSR: 35.34 – 36.31. OTR: 18.0 – 26.5. OCR: ⟨100-167/liter.

Phalacroma A

Identification incomplete because of scarcity and fragility of specimens. Observed only from Stations F and N, January 1966. OSR: 35.92 – 36.14. OTR: 19.5 – 21.0. OC: ⟨100/liter.

Phalacroma B

Identification incomplete because of scarcity and fragility of specimens. Recorded once from Station O, middepth, February 1967. OS: 35.63. OT: 17.5. OC: ⟨100/liter.

Phalacroma C

Identification incomplete because of scarcity and fragility of specimens. Recorded from Station E, November 1967. OS: 36.29. OT: 24.5. OC: ⟨100/liter.

Phalacroma spp.

Includes not more than five species or variants of the above species.

Podolampas bipes Stein (Figure 125)

Schiller (1937); Balech (1963); Abé (1966). Tow material from Station N, July 1966.

Podolampas reticulata Kofoid (Figures 126a, 126b)

Schiller (1937); Balech (1963); Abé (1966). Offshore species from Stations N and E, September and November 1967 respectively. Tow material from Station N, July 1966. OSR: 35.50 – 36.29. OTR: 24.5 – 28.5. OC: ⟨100/liter.

Podolampas elegans Schütt (Figure 127)

Schiller (1937); Balech (1963); Abé (1966). Observed from Station E, November 1967. OS: 36.29. OT: 24.5. OC: ⟨100/liter.

Podolampas palmipes Stein (Figures 128a, 128b)

Schiller (1937); Balech (1963); Abé (1966). Sporadic, primarily encountered at middle and offshore stations including E and M. Never abundant, recorded in all seasons. OSR: 34.92 – 36.45. OTR: 17.5 – 30.5. OCR: ⟨100-167/liter.

Podolampas spinifer Okamura (Figure 129)

Abé (1936); Schiller (1937); Balech (1963). Rare, primarily from offshore stations, summer through fall, including E and M. OSR: 35.78 – 36.30. OTR: 24.0 – 27.0. OC: ⟨100/liter.

Polykrikos hartmannii Zimmermann (Figure 130)

Schiller (1937). Sporadic, infrequent spring through fall at inshore and middle stations. Never abundant. Sometimes abundant, however in estuarine situations. OSR: 34.23 – 36.52. OTR: 19.5 – 30.5. OC: ⟨100/liter.

Polykrikos kofoidii Chatton

Kofoid and Swezy (1921). Rare, recorded at inshore stations, spring and winter. OSR: 34.03 – 35.39. OTR: 20.5 – 26.0. OCR: ⟨100-333/liter.

Polykrikos schwartzii Bütschli (Figures 131a, 131b)

Kofoid and Swezy (1921). Infrequent, fall through spring at inshore and middle stations. Sometimes abundant, however, in estuarine situations. OSR: 33.11 – 35.39. OTR: 18.5 – 31.0. OCR: ⟨100-333/liter.

Polykrikos spp.

Includes variants of the above.

Pronoctiluca acuta (Lohmann) Schiller (Figures 132a, 132b)

Kofoid and Swezy (1921). Observed primarily spring through fall 1967. Difficult species to detect, resembles small *Prorocentrum* valves. OSR: 35.62 – 36.41. OTR: 21.5 – 30.0. OCR: ⟨100-167/liter.

Prorocentrum aporum (Schiller) Abé

Schiller (1933). Rare, recorded from various stations including M. OSR: 34.44 – 35.93. OTR: 21.0 – 29.0. OC: ⟨100/liter.

Prorocentrum arcuatum Issel

Schiller (1933). Recorded from Station P, January 1967 and Station M, May 1966. OSR: 34.92 – 36.16. OTR: 24.5 – 26.0. OCR: ⟨100-167/liter.

Prorocentrum compressum (Ostenfeld) Abé (Figure 133)

Schiller (1933); Abé (1967a). Fairly common, primarily from middle and offshore stations including E and M. Sparse during late summer to early fall. Occurred in 16.4% live samples. OSR: 32.75 – 36.55. OTR: 17.0 – 31.2. OCR: ⟨100-167/liter.

Prorocentrum gracile Schütt (Figures 134a-134c)

Schiller (1933); Abé (1967a). Common, never frequent in summer through fall. Occasionally recorded in moderate concentrations. Abundant local estuarine species. Recorded from all stations including E and M. One specimen which appeared typical measured 54 μ long, 19 μ wide. Occurred in 20.8% live samples. OSR: 31.29 – 37.17. OTR: 18.5 – 31.5. OCR: ⟨100-2167/liter.

Prorocentrum mariae-lebourae (Parke and Ballantine) Abé

Parke and Ballantine (1957). Taxonomic position questionable. Rare, recorded in four samples. Probably spring and summer occurrence, neritic and estuarine species. OSR: 35.34 – 36.35. OTR: 22.0 – 31.0. OCR: ⟨100-167/liter.

Prorocentrum marinum (Tsenkovskiy) Abé

Schiller (1933). Rare, recorded from middle and offshore stations. OSR: 33.95 – 36.31. OTR: 20.5 – 23.0. OC: ⟨100/liter.

?Prorocentrum marinum var. *lima* (Schiller) Abé

Schiller (1933). Taxonomic position questionable. Recorded from Station O, July 1967, tow material.

Prorocentrum maximum Schiller (Figure 135)

Schiller (1933). Infrequent, least frequent in fall-winter. OSR: 32.63 – 36.14. OTR: 16.0 – 31.5. OCR: ⟨100-167/liter.

Prorocentrum micans Ehrenberg (Figures 136a, 136b)

Schiller (1933); Abé (1967a). Common, noticeably absent in April but occurring almost throughout the sampling program, most frequent from inshore stations in low to moderate concentrations. Observed cell length, 44 – 52 μ; body width 23-35 μ. Occurred in 17.4% live samples. OSR: 24.44 – 37.17. OTR: 14.0 – 32.0. OCR: ⟨100-2333/liter.

Prorocentrum oblongum (Schiller) Abé

Schiller (1933). Rare, recorded from Station P, August 1965 and from Station E, November 1967. OSR: 34.80 – 36.29. OTR: 24.5 – 32.0. OCR: ⟨100-333/liter.

Prorocentrum perforatum (Gran) Abé

Schiller (1933). Observed once from Station H, April 1966 in high numbers. OS: 34.68. OT: 21.5. OC: 5000/liter.

Prorocentrum pyriforme (Schiller) Abé (Figure 137)

Schiller (1933). Recorded twice from Station O, middepth, January 1967 and Station P, bottom, July 1967. OSR: 35.50 – 36.12. OTR: 18.8 – 30.5. OCR: ⟨100-167/liter.

Prorocentrum rostratum Stein (Figure 138)

Schiller (1933). Recorded only from Station F, bottom, December 1966. OS: 35.88. OT: 22.0. OC: ⟨100/liter.

Prorocentrum C

Sporadic, late 1965 through mid-1967. Never abundant. OSR: 34.68 – 36.38. OTR: 19.7 – 30.4. OCR: ⟨100-167/liter.

Prorocentrum spp.

Included no more than five additional species or variants of the above species.

Protoceratium areolatum Kofoid

Schiller (1937). Recorded only from Station H, middepth, June 1967. OS: 36.38. OT: 29.0. OC: ⟨100/liter.

Protoceratium reticulatum (Claparede and Lachmann) Bütschli (Figures 140a-140c)

Schiller (1937). Usually infrequent and sporadic, most frequent from middle and offshore stations, including E. OSR: 33.48 – 36.57. OTR: 17.5 – 27.5. OCR: ⟨100-167/liter.

Protoceratium spp.

Included variants of the above species.

Ptychodiscus noctiluca Stein (Figure 141)

Boalch (1969). Rare, recorded from Station E. OS: 36.29. OT: 24.5. OC: ⟨100/liter.

Pyrocystis fusiformis (W. Thompson) Murray (Figure 142)

Schiller (1937). Large species occurring sporadically. More frequent in fall through winter, never abundant. Mostly from middle and offshore stations including E and M. OSR: 34.97 – 36.41. OTR: 19.5 – 27.5. OC: ⟨100/liter.

Pyrocystis fusiformis f. *biconica* Kofoid (Figure 144)

Schiller (1937). Rare, recorded from offshore stations including E. Two live samples, two tow samples, similar occurrence to *P. fusiformis*. OSR: 36.04 – 36.29. OTR: 21.5 – 24.5. OC: ⟨100/liter.

Pyrocystis pseudonoctiluca W. Thompson (Figure 143)

Schiller (1937). Sporadic, fall through spring from middle and offshore stations including E. OSR: 35.57 – 36.45. OTR: 21.0 – 26.5. OC: ⟨100/liter.

Pyrocystis spp.

Probably includes aberrant forms.

Pyrodinium bahamense Plate (Figure 145)

Wall and Dale (1969). Sporadic, not recorded in winter. Most frequent from Station P. Other data indicate periodic bloom species. OSR: 30.49 – 36.52. OTR: 22.2 – 29.5. OCR: ⟨100-500/liter.

?Pyrodinium schilleri (Matzenauer) Schiller

Schiller (1937). Dubious species. This species may not be valid and may only be a variety of *P. bahamense*. OS: 35.35. OT: 29.3. OC: 167/liter.

Pyrophacus horologium Stein (Figures 146a, 146b)

Steidinger and Davis (1967). Common species noticeably absent or infrequent in winter. Almost exclusively recorded from inshore and middle stations and E and M, never abundant. Occurred in 19% live samples. Observed cell length, 26 – 48 μ; cell width, 38 – 143 μ (Steidinger and Davis, 1967). OSR: 31.46 – 36.59. OTR: 17.0 – 32.0. OCR: ⟨100-833/liter.

Pyrophacus horologium var. *steinii* Schiller (Figure 147)

Steidinger and Davis (1967). Fairly common variety, noticeably absent or reduced in winter and May-June. Distribution similar to the species. Also recorded from Stations E and M. OSR: 24.44 – 36.50. OTR: 17.5 – 32.0. OCR: ⟨100-333/liter.

Pyrophacus horologium form B_1 (Figure 148)

Steidinger and Davis (1967). Rare, recorded from only three samples, Station O. OSR: 34.75 – 35.54. OTR: 19.7 – 29.0. OC: ⟨100/liter.

Pyrophacus spp.

Includes variants of the above taxa.

Torodinium robustum Kofoid and Swezy (Figure 149)

Kofoid and Swezy (1921). Very common, along with the closely allied species *T. teredo*. Recorded from all stations at varying depths almost all year. More evident in late 1965 through late 1966. Also recorded from Station M. Occurred in 43.40% live samples. OSR: 24.44 – 36.53. OTR: 17.0 – 32.0. OCR: ⟨100-5500/liter.

Torodinium teredo (Pouchet) Kofoid and Swezy (Figure 150)

Kofoid and Swezy (1921). Very common, associated with *T. robustum's* distribution and occurrence, but this species more frequent in 1967. Occurred in 42.4% live samples. OSR: 24.44 – 37.17. OTR: 16.0 – 31.5. OCR: ⟨100-1833/liter.

Warnowia A (Figures 151a, 151b)

Observed only from Station P, November 1967. OSR: 34.13 – 34.20. OT: 19.0. OCR: ⟨100-333/liter.

Warnowia spp.

Includes no more than three species.

Unidentified armored species #1

Observed only in tow material, epizoic on hydromedusae, possibly new genus, new species.

DISCUSSION

Armored dinoflagellates dominated (frequency of occurrence). This would be expected considering armored forms accounted for 76% of the total taxa, the group being more diverse in this geographic area than unarmored forms. In addition, unarmored forms could not always be identified to species, e.g., *Gymnodinium* and *Gyrodinium*. Thus the clumping of forms under generic identity may mask any true dominance. However, it is estimated that there were no more than 25 unarmored species not identified; almost all of these were photosynthetic possessing chloroplasts. Certain genera exhibited definite distributional patterns with regard to distance from shore (horizontal distribution of inshore, middle and offshore stations). The following briefly illustrates the major distribution patterns of the genera encountered. Distribution of individual species is presented in the Species Account.

ARMORED GENERA

Amphisolenia: Photosynthetic. Most species occurred offshore with the prominent exception of *A. bidentata* which was encountered at all stations.

Blepharocysta: Non-photosynthetic. No horizontal trends except for *B. compressa(?)* which did not occur at inshore stations.

Ceratium: Photosynthetic. The designation of "sun and shade" species usually applied to this genus was not attempted because vertical distribution often depended on density gradients, tidal flux, currents and those parameters depended on time of collection, daily and seasonally. Most *Ceratium* species occurred at offshore, or offshore and middle stations. In contrast, *C. hircus(?)* was most frequent at inshore stations.

Ceratocorys: Photosynthetic. Recorded from offshore and middle stations. Absent or rare at inshore stations, as well as bottom samples.

Coolia: Photosynthetic. Inshore and bottom species. Usually found in the vicinity of oyster beds.

Dinophysis: Photosynthetic. *D. caudata* var. *pedunculata* was the most frequent representative at all stations and depths. The variety *diegenesis* occurred offshore, while variety *acutiformis* occurred mostly inshore and the variety *abbreviata* was recorded at middle stations. Other species predominately occurred at offshore and middle stations.

Diplopsalis: Non-photosynthetic. Diverse distribution, with exception noted in *D. lenticula* and *D. orbicularis* which were more frequent or present only at inshore and middle stations.

Fragilidium: Photosynthetic. Recorded only from inshore and middle stations.

Glenodinium: Photosynthetic. Most frequent at middle stations.

Gonyaulax: Photosynthetic. Most frequent at inshore and middle stations, rare offshore.

Heteraulacus: Photosynthetic. Frequently encountered at middle and offshore stations, rare or not present at inshore stations.

Ornithocercus: Non-photosynthetic. Recorded from middle and offshore stations, but not encountered at inshore stations.

Oxytoxum: Photosynthetic. Mostly recorded at offshore stations.

Peridinium: Most non-photosynthetic. Some species only occurred at offshore stations (*P. curvipes, P. pallidum* var. *schilleri, P. pyriforme,* "U"), at middle stations (*P. solidicorne, P. steinii,* "L", "N", "O") and at inshore stations (*P. abei, P. leonis* f. *matzenaueri, P. quinquecorne,* "P"). Oceanic species, e.g., *P. elegans, P. elegans* var. *granulata, P. fatulipes* and *P. longipes* were rare or not recorded at inshore stations.

Phalacroma: Most photosynthetic. Usually offshore species, few recorded for inshore except for *P. argus.*

Podolampas: Non-photosynthetic. Mostly offshore, very few records inshore (exception: *P. palmipes*).

Prorocentrum: Photosynthetic. *P. compressum,* a common species, occurred more at middle and offshore stations, while *P. micans* another common species, was encountered mostly inshore.

Protoceratium: Photosynthetic. *P. reticulatum* was least frequent inshore while *P. aereolatum* was encountered inshore, mid-depth.

Pyrodinium: Photosynthetic. Recorded from inshore to offshore, sporadically.

Pyrophacus: Photosynthetic. Frequent at inshore and middle stations, rare offshore.

UNARMORED GENERA

Actiniscus: Non-photosynthetic. Offshore, surface samples.

Amphidinium: Photosynthetic. Recorded mostly at inshore and middle stations, rare or not present offshore except for *A. curcubita* and "B".

Cochlodinium: Mostly non-photosynthetic. No trend noted except for "A" which was least encountered inshore.

Dissodinium: Photosynthetic. No inshore records. Stage V was offshore, surface.

Gymnodinium: Mostly photosynthetic. Wide diversity among species. *G. coeruleum* was least frequent inshore, *G. splendens* was rare offshore except for bottom samples.

Gyrodinium: Mostly photosynthetic. Usually rare offshore with exceptions noted: *G. caudatum* and *G. falcatum.*

Katodinium: Photosynthetic. Widely distributed, no horizontal trends.

Kofoidinium: Non-photosynthetic. Recorded at middle and offshore stations, not encountered inshore.

Oxyrrhis: Non-photosynthetic. Mostly recorded at inshore and middle stations, rare offshore.

Polykrikos: Mostly non-photosynthetic. Sporadic occurrence at inshore and middle stations, no offshore records.

Pronoctiluca: Non-photosynthetic. Infrequent at inshore and middle stations, least encountered offshore.

Pytchodiscus: Non-photosynthetic(?). Only observed offshore.

Pyrocystis: Photosynthetic. Mostly middle and offshore stations, rare inshore.

Torodinium: Photosynthetic. No horizontal trends.

Warnowia: Non-photosynthetic. "A" inshore records only.

Many problems arise in an effort to determine vertical occurrence and stratification of marine dinoflagellates. For example, variations in many pertinent factors including collection time, weather conditions, nutrient concentrations, currents and specific physiological differences make direct comparisons meaningless.

Stations F and N were usually sampled under low light conditions. Contrarily, inshore stations P and H were sampled later in the day (1200-1800) and surface waters had the greatest dinoflagellate concentrations. This may explain the appearance of certain species in bottom samples at offshore stations and in surface samples at inshore stations, e.g., *Gymnodinium splendens, Gymnodinium breve* and *Pyrodinium bahamense. Ceratium tripos* var. *atlanticum, Diplopsalis lenticula* var. *asymmetrica* and *Dinophysis caudata* var. *pedunculata* were more frequent in surface samples and less frequent in middepth and bottom. These distribution patterns could be caused by variations in turbidity.

Dinoflagellate densities were highest at inshore stations and progressively decreased further offshore (Appendix VI). Comparison of offshore, middle and inshore stations shows that middle stations (G and O) had the greatest species diversity. Offshore stations were second and inshore stations had the least variety. Middle stations perhaps represent an overlap area between neritic/estuarine and oceanic/neritic species. If the offshore and middle stations are combined, they represent about 1.5X the number of species encountered at inshore stations. Inshore stations exhibited higher dinoflagellate counts but had less species diversity. Offshore stations exhibited greater species diversity but low abundance. This pattern agrees with Hulburt's (1963a).

The relatively great difference in counts between inshore and offshore stations may not be representative of a difference in biomass since the high inshore counts were generally of small species while larger species occurred offshore.

Of the 232 taxa, 89 occurred in all seasons (Appendix II), 71 were recorded for only one of the seasons and the remaining taxa occurred in more than one season but not yearly. Photosynthetic dinoflagellates outnumbered non-photosynthetic forms by 138 to 94. Fifty-eight photosynthetic taxa occurred in all seasons as compared to 31 non-photosynthetic forms. Most of the unidentified species were photosynthetic.

Offshore stations F and N had few peaks of abundance except for fall months, while stations H and P had sporadic peaks around 5-7 x 10^4 cells/liter usually in summer and fall months. Middle stations G and O had peaks primarily in summer and fall months. Occasionally winter and spring peaks were encountered in 1966 at various stations. The data demonstrate that cyclic events do not necessarily coincide year to year. Fall and winter concentrations of 1965-1966 were much higher than for the same period in 1966-1967. In general, dinoflagellates were not as abundant in 1967 at all stations as in 1966. The largest peak, Station N, in October 1967 resulted primarily from a bloom of *Gymnodinium breve.*

Even though Station N was sampled only a few days after F (locations identical), there were considerable fluctuations in population composition. Certain species of course, e.g., *Torodinium robustum*, occurred regularly. This reinforces the observations of Steidinger, Davis and Williams (1967a) that fluctuations in species diversity or densities take place within short periods of time. Data interpretation should consider such fluctuations.

With the exception of *Oxyrrhis marina* and *Peridinium excentricum*, all species we have observed in bloom condition (Appendix IV), have been photosynthetic. Even in Hourglass material the photosynthetic species are most abundant and often dominate a sample.

Live samples, even though necessary for identification of fragile forms, apparently represent a minimum in species diversity. In addition, filtration of the entire sample yielded additional species (0-29) not detected in subsamples (Appendix V), and preserved tow samples revealed armored dinoflagellates not observed in live samples or their filtered residues.

Appendix III lists those species and varieties which appeared to be significant forms. This was based on frequency of occurrence in live and tow samples. Biomass, based on volume, was calculated for some species. This data indicates that large but relatively sparse species may actually dominate a given sample if biomass is used as a basis for standing stock determinations. Since some *Ceratium* species apparently have seasonal fluctuations in the size of horns (Raymont, 1963), a biomass determination (by volume) might show seasonal variation. However, size range varied sample to sample so strongly that a seasonal variation could not be statistically verified.

Phytoplankton populations in the Gulf of Mexico are apparently extremely rich in terms of species diversity. The total number of dinoflagellates reported from the Gulf of Mexico and contiguous waters represents over one-third of all known species. Saunders and Glenn (1969) obtained similar information on the richness of diatom populations.

ADDENDUM

After this paper was submitted for publication, a dinoflagellate bloom occurred in Tampa Bay, Florida (July 1970). The organism was identified as *Heteraulacus reticulatus* (Kofoid and Michener), as it had been the previous year. Upon closer examination it appeared to be an undescribed species of *Gonyaulax*. Depending on the interpretation of the apical and precingular plates (4', 6'' or 3', 7'') and the antapical posterior intercalary and sulcal plates (1p, 8s, 1'''' or 0p, 7s, 3''''), this organism would fit into either genus. It is suggested here that the organism is indeed a new species of the *Gonyaulax* "*Catenella* Group." It is also suggested that members of *Heteraulacus* should be re-evaluated. In assigning this new species to *Gonyaulax*, another problem was encountered. The *Catenella* Group (G. *acatenella, G. catenella, G. cohorticula, G. concava, G. conjuncta, G. fratercula, G. monilata, G. orientalis, G. tamarensis, G. tamarensis* var. *excavata,* and *G. washingtonenis*) is considerable different in size, shape, and plate configuration than *Gonyaulax sensu stricto*. A paper entitled "*Gonyaulax balechii*, nov. sp. and a Discussion of the Genera *Gonyaulax* and *Heteraulacus*" is in preparation.

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PHOTOGRAPHIC PLATES

There are 45 photographic plates accompanied by their respective legends. All species are arranged alphabetically with the exception of those on Plate XLI. *Ceratium candelabrum* var. *depressum, C. schroeteri* and *C. vultur* were unintentionally omitted from the alphabetical sequence of those species recorded in Hourglass material. Plates I through XLI represent Hourglass results, while Plates XLII through XLV represent additional species collected from the Gulf of Mexico (including Florida west coast estuarine waters) and the Florida and Yucatan Straits, these taxa are not discussed in the text.

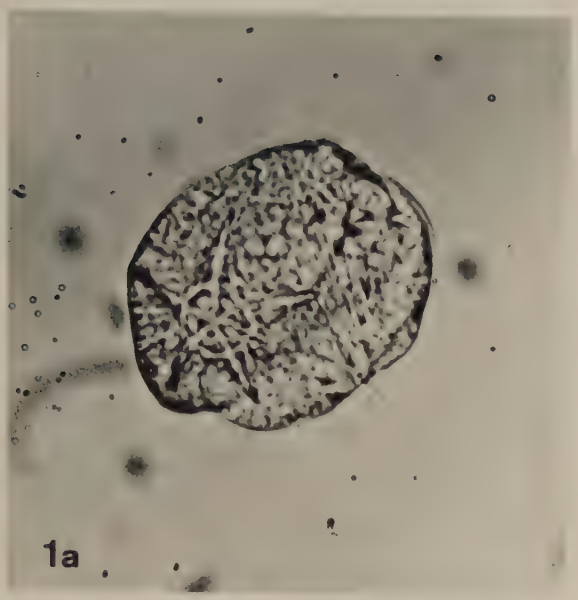
PLATE I

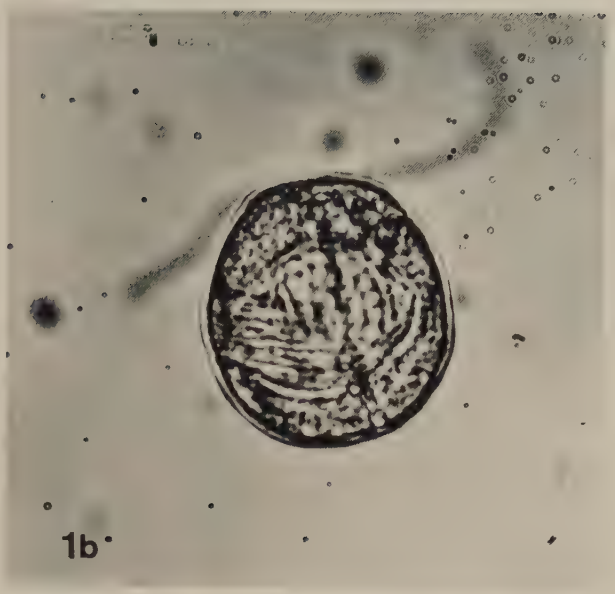
Figure 1. *Actiniscus pentasterias.* Live. Non-photosynthetic. Encysted cell. a) Head on view of internal star-shaped structure. b) Side view of internal structures (Paired) and associated rod packet. In motile stage resembles gymnodinioid.

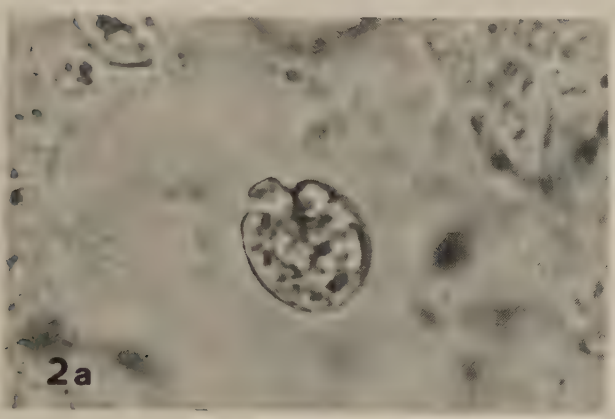
Figure 2. *Amphidinium carteri.* Live. Photosynthetic. a) Ventral view. Similar to *A. kelbsii*, but smaller. Pigmentation yellowish. 14 μ long. b) Lateral view. Note anvil-like epicone.

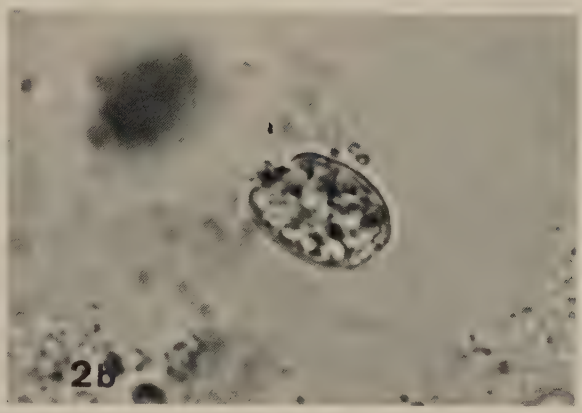
Figure 3. *Amphidinium curcubita.* Live. Photosynthetic. Lateral view. Hypocone ribbed, broader than epicone, almost appears inflated. 66 μ long.

Figure 4. *Amphidinium scissum* (?). Live. Photosynthetic. Lateral view. Round in cross section, hypocone ribbed, broader than epicone. Nucleus posterior. Cingulum displaced about 1X. 64 μ long.









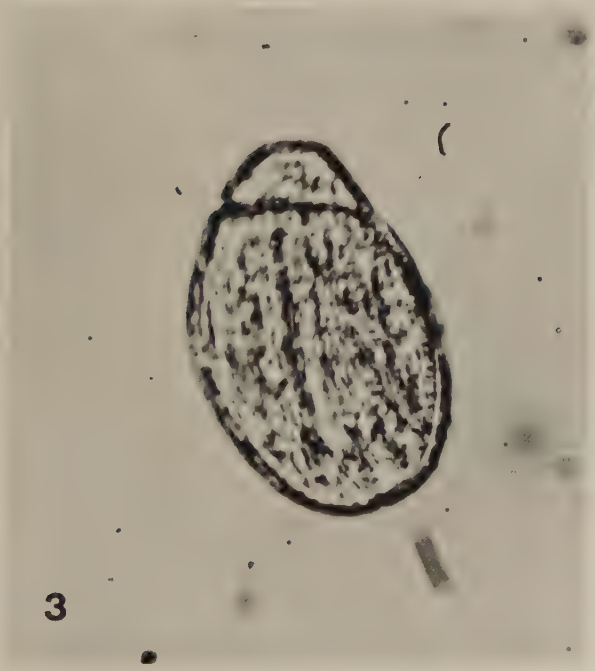
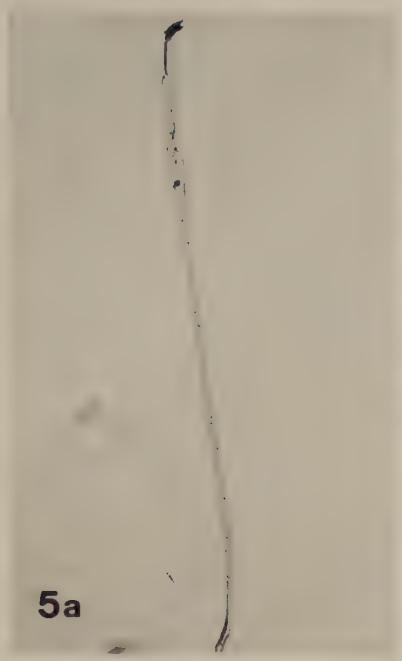


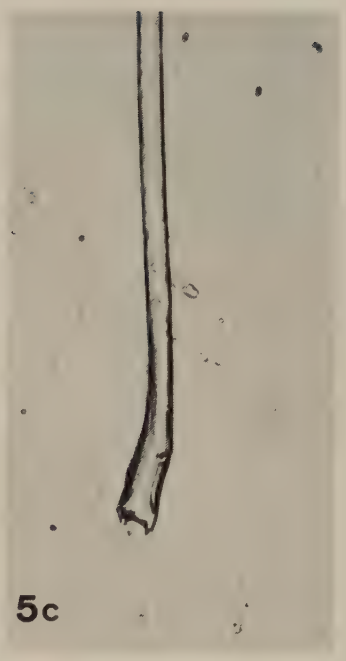
PLATE I

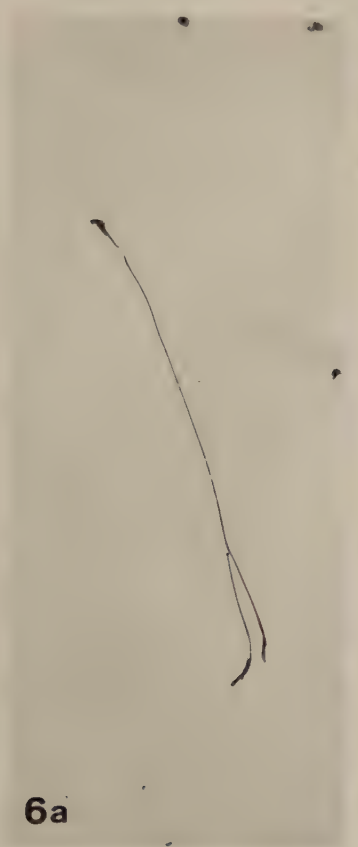
PLATE II

Figure 5. *Amphisolenia bidentata.* Preserved. Photosynthetic. a) Lateral view. Cingulum represented by two dark lines at the top of the cell, epitheca extremely short, hypotheca occupies most of cell length. 806 μ long. b and c) Enlargement showing antapical process and spines.

Figure 6. *Amphisolenia bifurcata.* Live. Photosynthetic. a) Semi-lateral view. Hypotheca bifurcate posteriorly, each branch broadened with antapical process (foot-like). 1,056 μ long. b) Phase contrast. Head, neck and anterior body area. c) Phase contrast. Posterior area with broadened bifurcations.







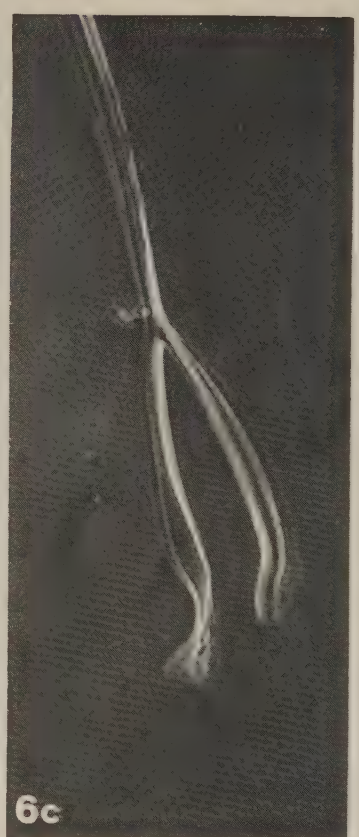


PLATE II

PLATE III

Figure 7. *Amphisolenia* sp. Live. Photosynthetic. a and b) Two opposing views to illustrate antapical process (with 4 spines) and distal body curvature. 326 μ long.

Figure 8. *Blepharocysta compressa* (?). Live. Non-photosynthetic. This possibly could be a new species of *Blepharocysta.* Nucleus prominent, typically fingerprint-like. 87 μ wide.

Figure 9. *Blepharocysta splendor-maris.* Live. Non-photosynthetic. a) Cell either ingesting *Peridinium trochoideum* or in the first stages of extracellular digestion. 43 μ wide. It is thought that the photomicrographs for this species demonstrate stages in extracellular digestion on the part of saprophytes having pusules. b) Cell with attached pigment mass. 42 μ wide.

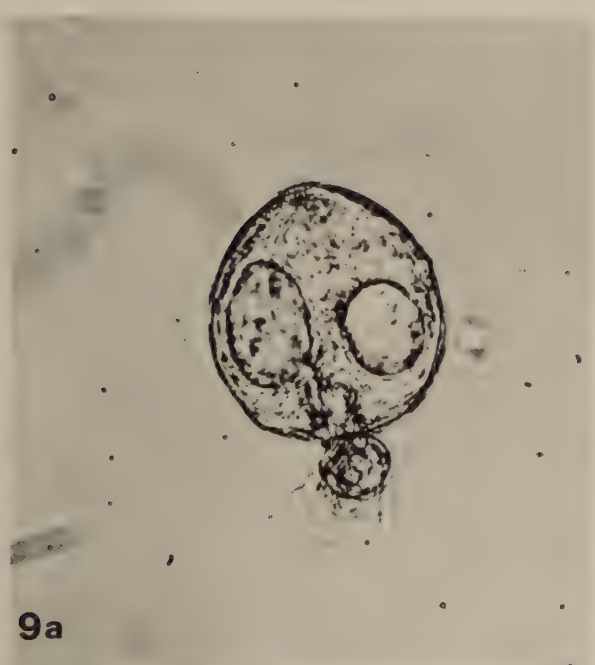


PLATE III

PLATE IV

Figure 10. *Ceratium belone.* Preserved. Photosynthetic. Lateral view. Epitheca gradually tapered, not abruptly forming apical horn. Right antapical shorter than left. 796 μ long.

Figure 11. *Ceratium bigelowii.* Preserved. Photosynthetic. a and b) Reduced right antapical horn, left horn long and gently bent. Body inflated at proximal end of epitheca. Epitheca – 49 μ wide.

Figure 12. *Ceratium buceros* f. *tenue.* Preserved. Photosynthetic. Dorsal view. Small species, apical horn offset and bent to right. Body–41 μ wide.

NOTE: *Ceratium candelabrum* var. *depressum* Fig. 153 on Plate XLI.

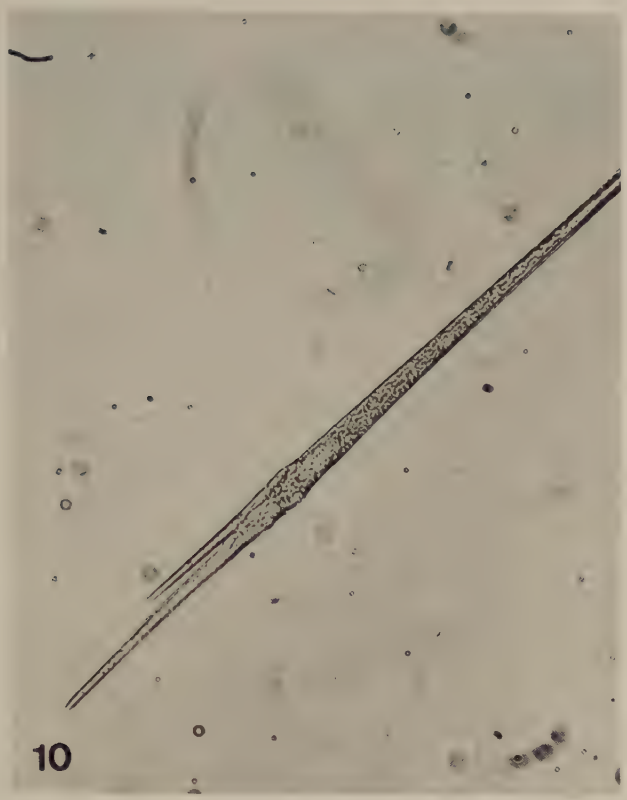


PLATE IV

PLATE V

Figure 13. *Ceratium carriense.* Preserved. Photosynthetic. a) Dorsal view. Large species with divergent antapical horns. Body – 70 μ wide. b) Enlarged dorsal view showing origin and curvature of antapical horns. Body convex on left, concave on right. Compare to antapical horns of variety.

Figure 14. *Ceratium carriense* var. *volans.* Preserved. Photosynthetic. a) Ventral view. Large species with antapical horns widely separated. Body – 70 μ wide. b) Enlarged ventral view, antapical horns almost directed at a 90° angle from body.

13a

13b

14a

14b

PLATE V

PLATE VI

Figure 15. *Ceratium concilians.* Live. Photosynthetic. Ventral view. Note origin and bend of apical horn as well as the right antapical directed dorsally. Surface not as rugose as in *C. gibberum* f. *dispar.239* μ long.

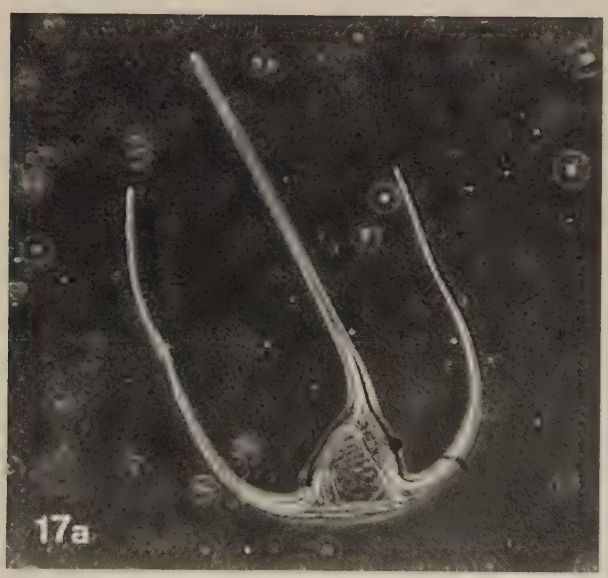
Figure 16. *Ceratium contortum* var. *contortum.* Live. Photosynthetic. a) Phase contrast. Dorsal view. Apical horn curved proximally, right antapical recurved past apical horn. Body – 71 μ wide. b) Ventral view of developing specimen. Recently divided, antapex rounded, apical horn offset to left. Right antapical recurved distally. Body – 77 μ wide.

Figure 17. *Ceratium contortum* var. *karstenii.* Preserved. Photosynthetic. a) Phase contrast. Ventral view. Origin of apical horn to the side, both antapicals with slight bend. Body approximately 80 μ wide.

15

16a

16b



17a

PLATE VI

PLATE VII

Figure 17. *Ceratium contortum* var. *karstenii.* b) Dorsal view. Offset apical horn, hypotheca not rounded. Right antapical not recurved nor directed towards body. Body—81 μ wide.

Figure 18. *Ceratium declinatum* f. *normale.* Live. Photosynthetic. Dorsal view. Apical horn slightly offset to left. Epitheca not triangular.

Figure 19. *Ceratium extensum.* Live. Photosynthetic. Extremely long species, greater than 1000 μ.. Epitheca and hypotheca straight, otherwise similar to *C. fusus*. Body — 31 μ wide.

Figure 20. *Ceratium furca.* Photosynthetic. a) Live. Ventral view. Tapered epitheca, antapical horns unequal, left longer. Approximately 260 μ long. b) Preserved. Dorsal view. Recently divided cell showing thicker parental theca, hyaline developing theca and line of fission. 260 μ long.

PLATE VII

PLATE VIII

Figure 21. *Ceratium fusus.* Photosynthetic. a) Live. Lateral view. Left antapical horn gently curved, occasionally straight; right horn rudimentary. 390 μ long. b) Preserved. Thecae from a dividing cell, oblique longitudinal fission. 381 μ long.

Figure 22. *Ceratium gibberum* f. *dispar.* Live. Photosynthetic. a) Ventral view. Specimen with fully formed right antapical horn curved dorsally past apical horn. Body – 95 μ wide. b) Dorsal view. Apical horn offset to left. Antapical horns not fully developed. Antapex rounded. 424 μ long.

21a

21b

22a

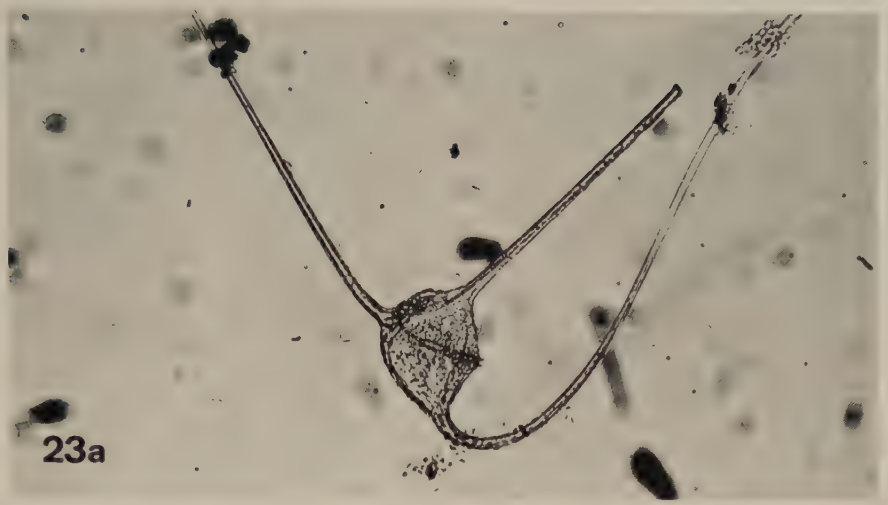
22b

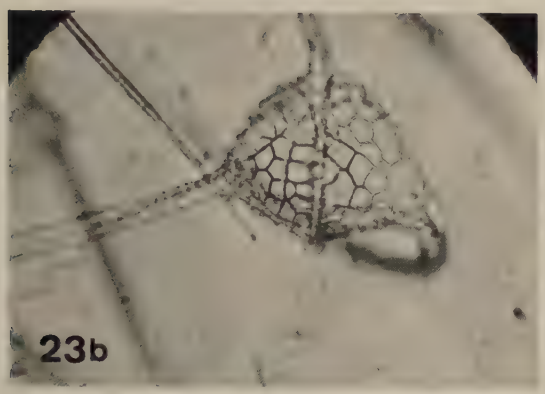
PLATE VIII

PLATE IX

Figure 23. *Ceratium hexacanthum.* Photosynthetic. a) Preserved. Ventral view. Right horn outwardly directed, left horn curved towards body. Some specimens with right horn curved beyond apical horn. 163 μ long. b) Preserved. Dorsal view. Body strongly reticulated. c) Disassociated. Phase contrast. Ventral area and associated sulcal plates. Knobby ventral area composed of 3 large plates and 1 small plate.

Figure 24. *Ceratium hircus* (?). Live. Photosynthetic. a) Epitheca gently tapered, broader than *C. furca.* Antapicals equal, divergent, right horn directed ventrally. Most common *Ceratium* occurring along Florida's west coast. This form has been identified as *C. furca* by some workers. b) Aberrant grown in artificial media. With 3 antapical horns, not *C. hirundinella.*





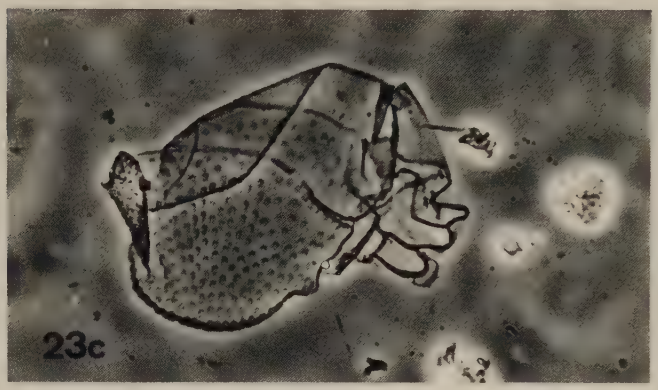


PLATE IX

PLATE X

Figure 25. *Ceratium inflatum.* Preserved. Photosynthetic. Inflated body, left antapical horn distally bent. 1,054 μ long.

Figure 26. *Ceratium kofoidii.* Crushed. Photosynthetic. Phase contrast. Dorsal view. Broad epitheca and hypotheca. Antapical horns thin and serrated, short apical horn, delicate cell. 24 μ wide.

Figure 27. *Ceratium longirostrum.* Preserved. Photosynthetic. Semi-lateral view. Epitheca gently tapered and curved distally; hypotheca slightly curved distally. 713μ long.

Figure 28. *Ceratium lunula.* Live. Photosynthetic. Dorsal view. Direction and curvature of thick antapical horns characteristic. Cell appears recently detached from parent cell. Body – 102 μ wide.

PLATE X

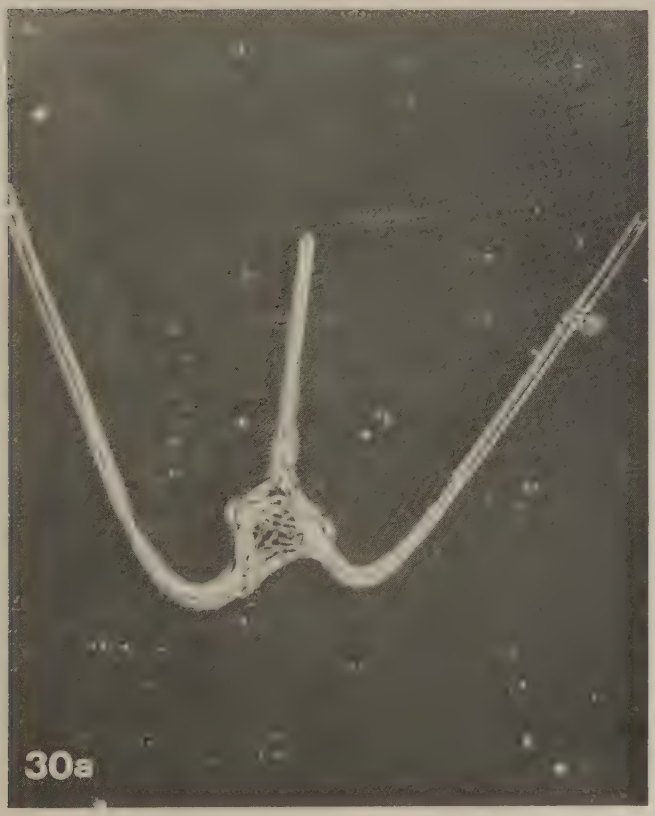
PLATE XI

Figure 29. *Ceratium macroceros* var. *gallicum.* Preserved. Photosynthetic. a) Dorsal view. Delicate cell with apical horn offset slightly to left. Antapical horns directed downward then curved. b) Phase contrast. Ventral view. Origin of apical horn and curvature of antapicals characteristic. Body – 52 μ wide.

Figure 30. *Ceratium massiliense.* Photosynthetic. a) Preserved. Phase contrast. Dorsal view. Note typical curvature and direction of antapical horns. Compare to *C. carriense* and *C. trichoceros.* b) Live. Aberrant observed in culture. Note bifurcation of antapical horns. Perhaps those species with palmate or branching antapical horns are phenotypes rather than genotypes. 316 μ long.

29a

29b



30a

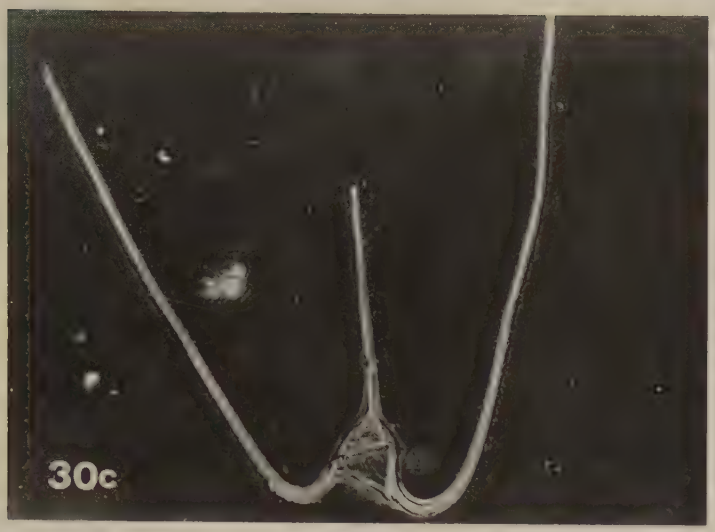
30b

PLATE XI

PLATE XII

Figure 30. *Ceratium massiliense.* c) Preserved. Phase contrast. Ventral view. 462 μ long. d) Phase contrast. The 3 large and 1 small tuberculate plates represent the ventral area. Tubercules about 1.5 μ in diameter. e) Disassociated. Phase contrast. Knobby, hyaline ventral and sulcal plates disassociated from theca.

Figure 31. *Ceratium pentagonum* var. *tenerum.* Preserved. Photosynthetic. Body broadly pentagonal, antapical horns well separated, straight and short. Surface vermiculate, suture markings evident. 102 μ long.



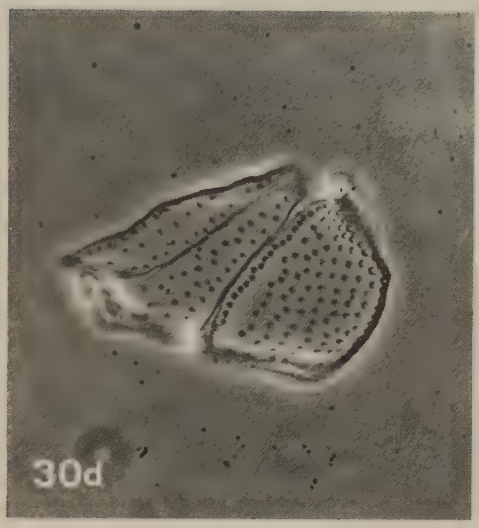


PLATE XII

PLATE XIII

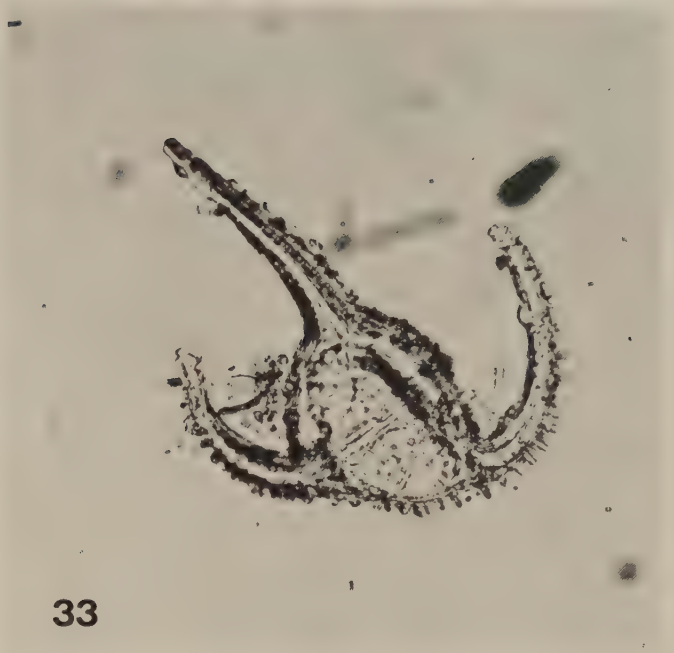
Figure 32. *Ceratium pulchellum.* Live. Photosynthetic. Ventral view. Delicate cell, long apical horn, short antapical horns, right shorter and closer to body. Body – 60 μ wide.

Figure 33. *Ceratium ranipes.* Preserved. Photosynthetic. Ventral view. This specimen is *C. ranipes* without characteristic palmate antapical horns. Antapical and apical horns heavily spined. Body – 105 μ wide.

Figure 34. *Ceratium symmetricum* var. *coarctatum.* Live. Photosynthetic. Phase contrast. Ventral view. So named because of the almost symmetrical curvature of antapical horns. Apical horn with slight curvature. Body – 56 μ wide.

Figure 35. *Ceratium teres.* Photosynthetic. a) Preserved. Phase contrast. Dorsal view. Body slightly pentagonal. Antapical horns serrate and characteristically narrower proximally. 151 μ long. b) Live. Phase contrast. Dorsal view. Broader cell, but antapical horns still characteristically pointed.

NOTE: *Ceratium schroteri* Fig. 154 on Plate XLI



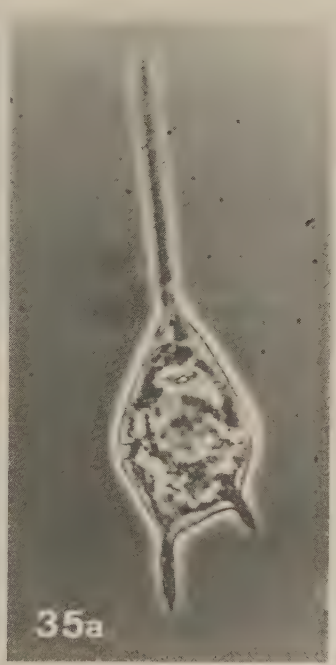
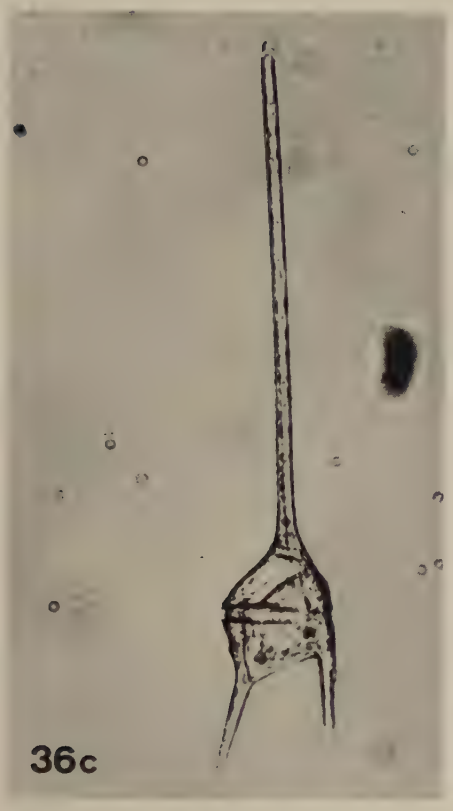


PLATE XIII

PLATE XIV

Figure 36. *Ceratium trichoceros.* Live. Photosynthetic. Large species with small delicate body. a) Dorsal view. Right side of cingulum barely distinguishable. Note even curvature and span of antapical horns. 303 μ long. b) Aberrant observed in culture, ill-defined body mass and horns. c) Dorsal view. Daughter cell of Figure 36d, specimen 35 μ wide. Could be mistaken for *C. lineatum* or a new species if found alone in plankton samples. d) Parental cell of Figure 36d.

Figure 37. *Ceratium tripos* var. *atlanticum.* Photosynthetic. a) Live. Ventral view. Apical horn offset to left, hypotheca rounded, antapical horns slightly curved towards body. Body – 74 μ wide. b) Preserved. Ventral view. Curvature of antapical horns more evident.



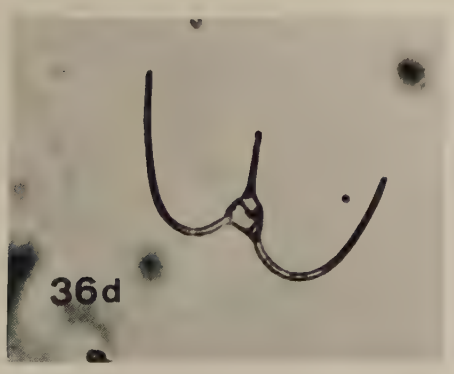


PLATE XIV

PLATE XV

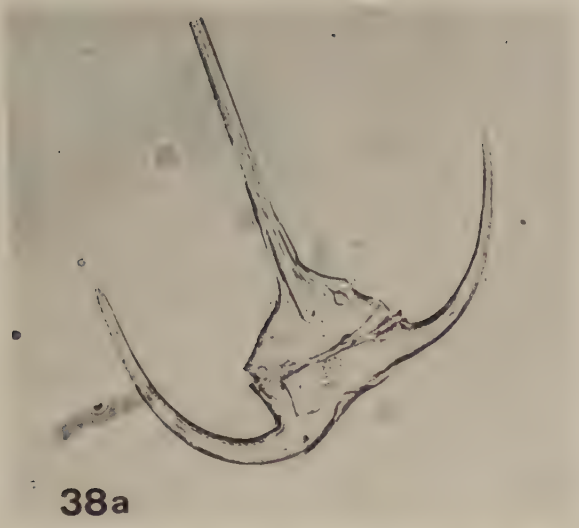
Figure 38. *Ceratium tripos* var. *ponticum.* Photosynthetic. a) Crushed and cleared. Dorsal view. Broader and more angular than *C. tripos* var. *atlanticum.* Right horn directed outward. 220 μ long. b) Preserved. Ventral view. Similar morphology.

Figure 39. *Ceratium vultur* var. *sumatranum.* Preserved. Photosynthetic. Chain forming variety with antapical horns directed outward. Note regeneration of antapicals. Bottom cell – 56 μ wide.

Figure 40. *Ceratium* sp. Live. Photosynthetic. Phase contrast. Dorsal view showing curved apical horn and short antapical horns. Approximates *C. dens*, however this could be a developing stage of another species. Body – 67 μ wide.

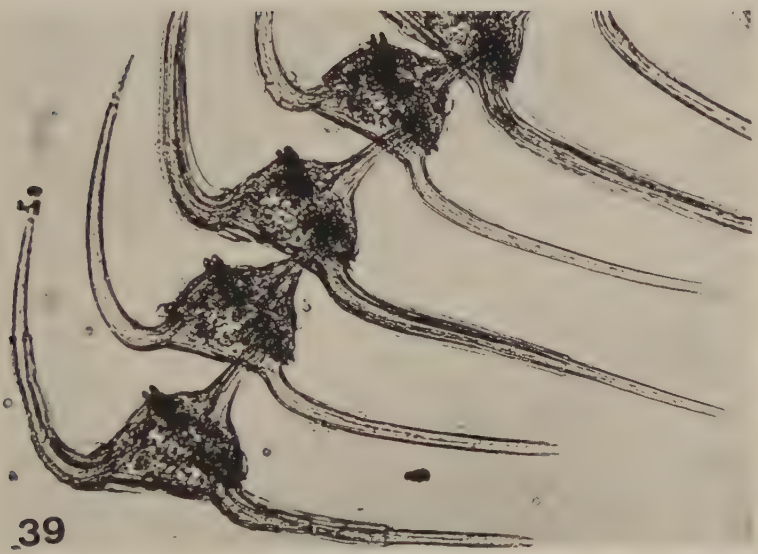
Figure 41. *Ceratocorys armata.* Live. Photosynthetic. a) Four short antapical spines originate from antapical plate. Robust, heavily armored species. Cingular lists horizontally directed, short and supported by ribs. Hypotheca – 63 μ long. b) Crushed. Phase contrast. Cell with thickly aerolated surface, raised sutures.

NOTE: *Ceratium vultur* Fig. 155 on Plate XLI



38a

38b



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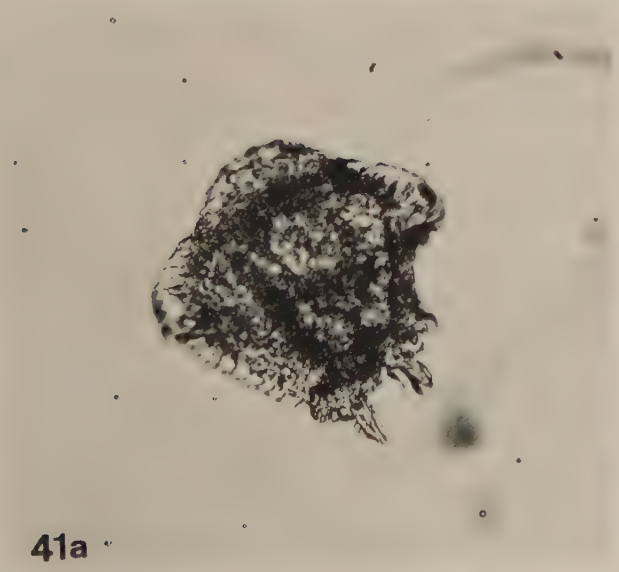

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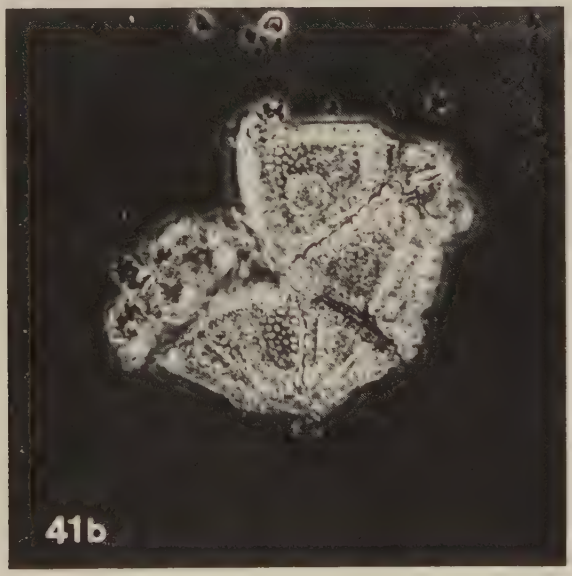


41b

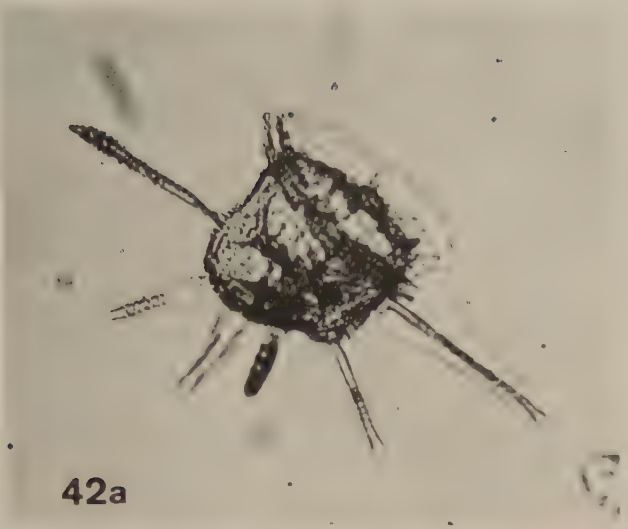
PLATE XV

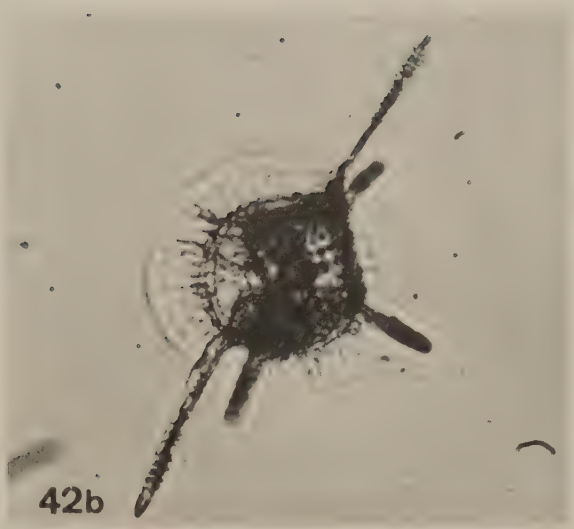
PLATE XVI

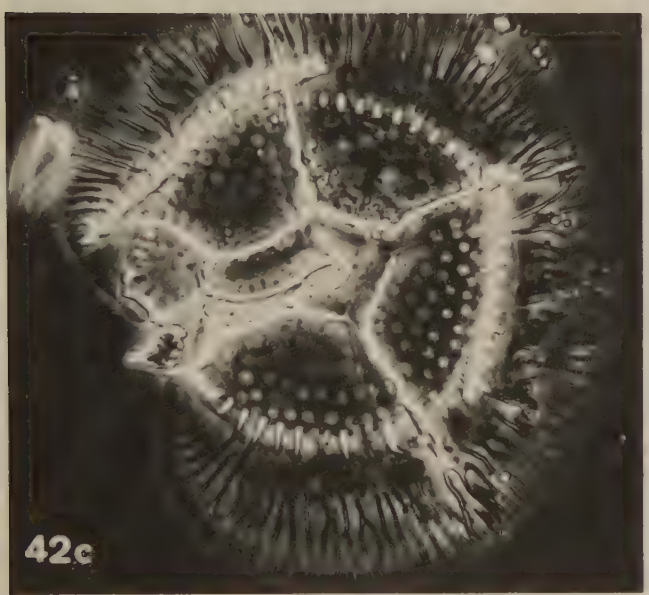
Figure 42. *Ceratocorys horrida.* Photosynthetic. a) Live. Lateral view. Illustrates winged spines and short cingular lists. b) Live. Antapical view. Characteristic posterior origin of 4 shorter spines, 3 discernible. 61 μ wide. c) Disassociated. Phase contrast. Apical view showing arrangement of plates, cingular list and closing platelet. d) Disassociated. Phase contrast. Note surface structure, spine origin on postcingular, as well as adjacent separated sulcal area.

Figure 43. *Cochlodinium citron.* Live. Non-photosynthetic. Cell dividing, 2 nuclei observed. Note torsion of cingulum. 35 μ wide.

Figure 44. *Cochlodinium A.* Live. Photosynthetic. Division products of original parental cyst. Cingulum torsion simple. 48 μ long.







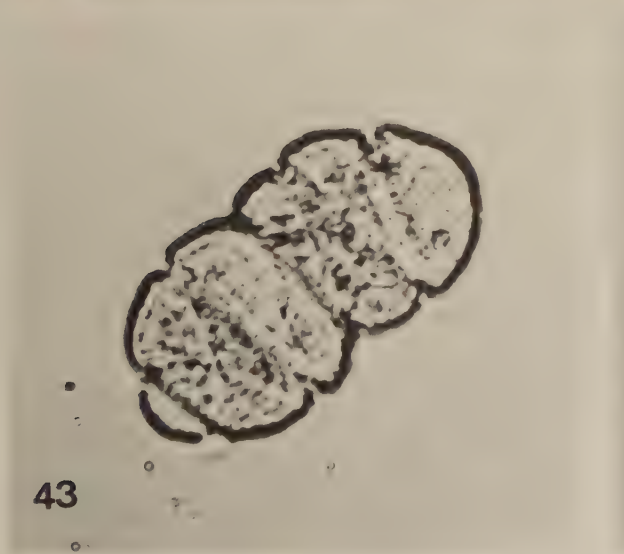


PLATE XVI

PLATE XVII

Figure 45. *Cochlodinium* B. Live. Non-photosynthetic. Encysted specimen. Note cingulum torsion and sulcal notching. 52 μ long.

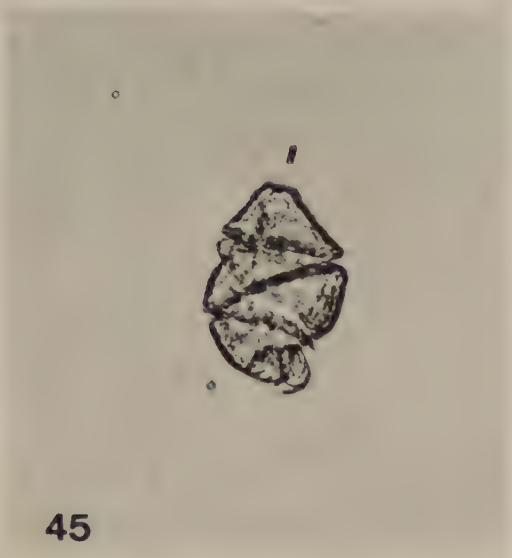
Figure 46. *Dinophysis caudata* f. *acutiformis.* Live. Photosynthetic. Lateral view. Two recently divided schizonts. Cingular lists directed upward and quite discernible. 77 μ long.

Figure 47. *Dinophysis caudata* var. *pedunculata.* Preserved. Photosynthetic. Lateral view. Two recently divided cells. Hypotheca attenuated in pendulum-like process. Approximately 40 μ deep. Many forms encountered between the species and this variety.

Figure 48. *Dinophysis hastata.* Preserved. Photosynthetic. Lateral view. Epitheca limited, but cingular lists extend beyond anterior periphery, support rib (R_3) curved posteriorly. Posterior sail centrally located. Body – 67 μ long without lists.

Figure 49. *Dinophysis ovum.* Live. Photosynthetic. Lateral view. Body subovate, anterior cingular list fu[illegible]-shaped, almost 1/2 body depth. 46 μ long.

Figure 50. *Dinophysis* C. Live. Photosynthetic. Phase contrast. Lateral view. Small species with short cingular lists directed anteriorly. 30 μ wide.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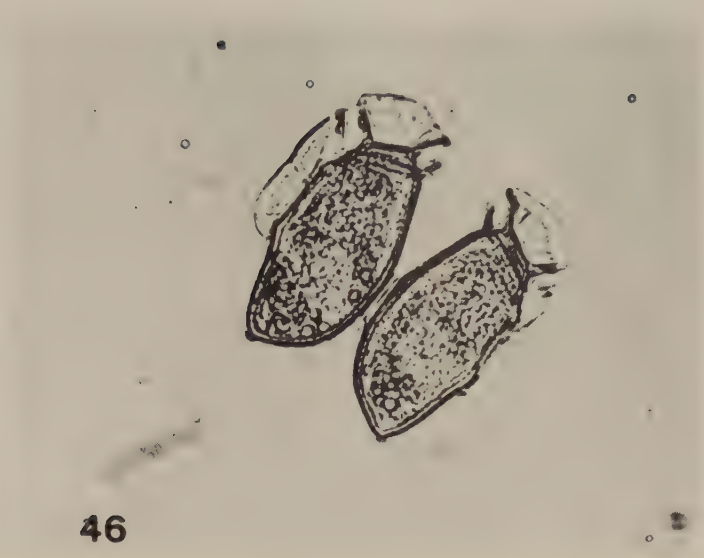
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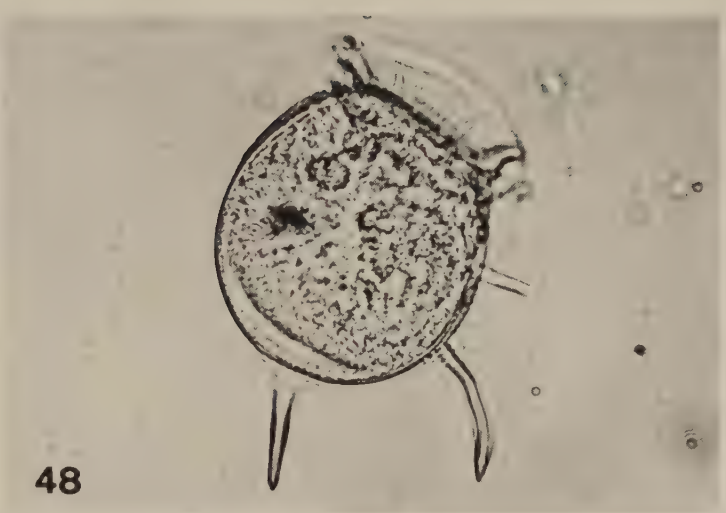
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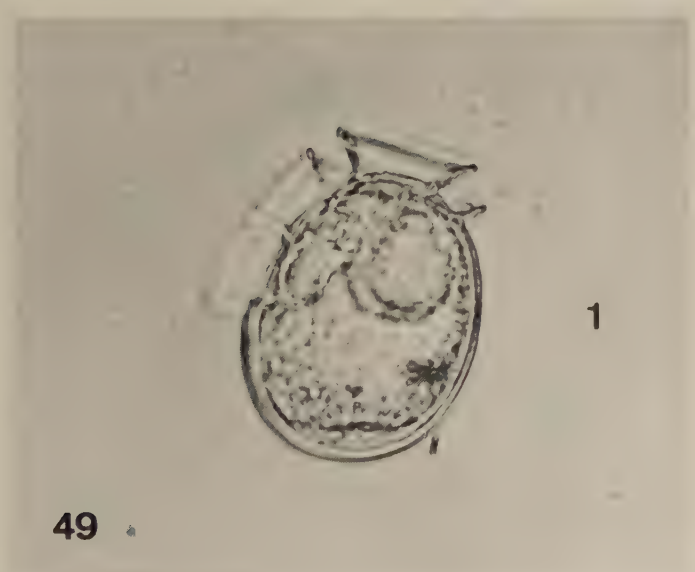
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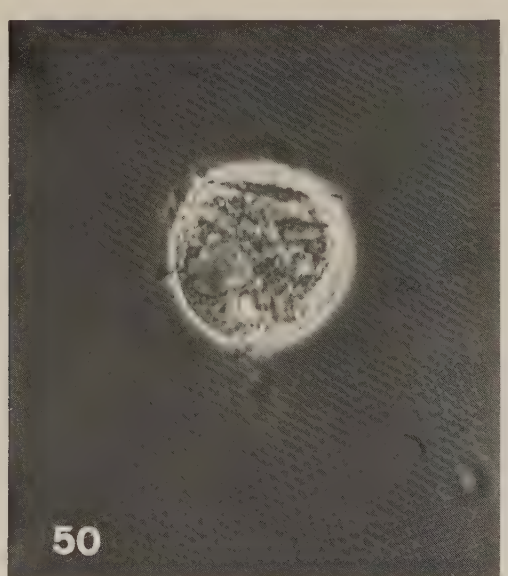

50

PLATE XVII

PLATE XVIII

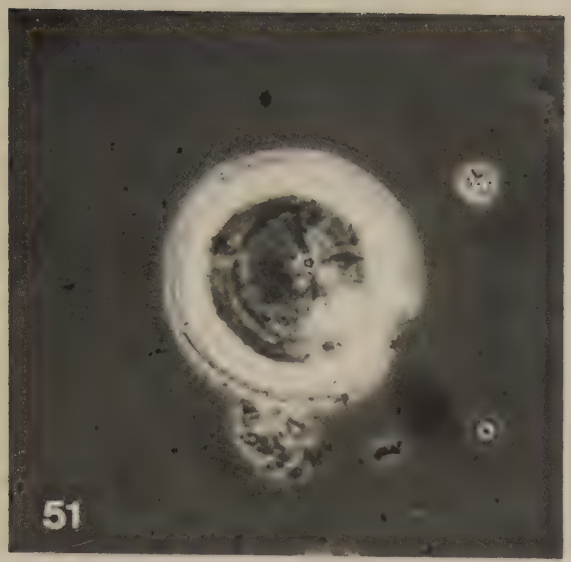
Figure 51. *Diplopsalis lenticula.* Preserved. Non-photosynthetic. Phase contrast. Apical view showing 3 apical plates. 42 μ wide.

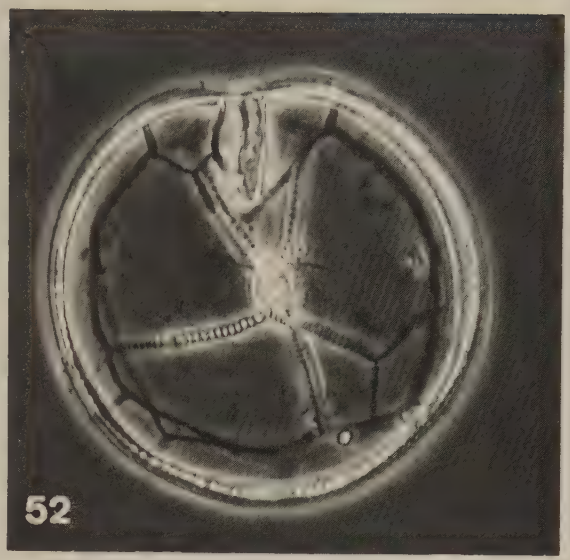
Figure 52. *Diplopsalis lenticula* f. *asymmetrica.* Preserved. Non-photosynthetic. Phase contrast. Cleared view of the epitheca over hypotheca. Note unusual intercalary striae, the anterior intercalary plate and suture line between the 2 antapical plates. 82 μ wide.

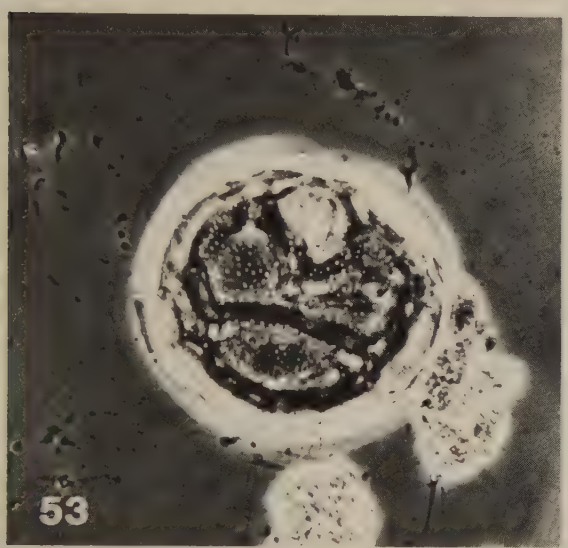
Figure 53. *Diplopsalis lenticula* f. *minor.* Preserved. Non-photosynthetic. Phase contrast. Two views, one showing 1'-4' and 1 anterior intercalary, the other showing the sulcal area and adjacent large single antapical plate with poroids. 66 μ deep.

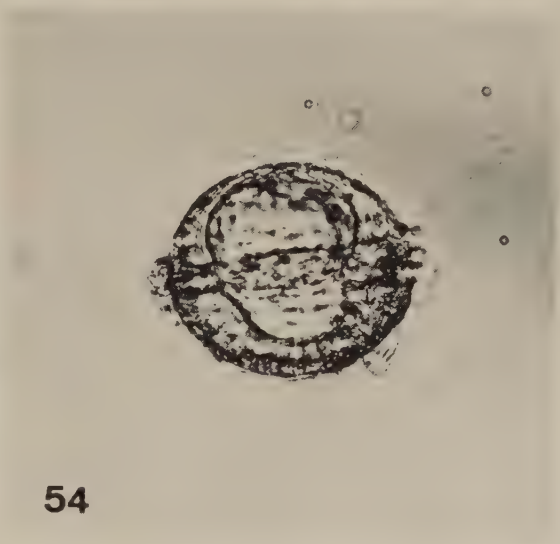
Figure 54. *Diplopsalis* sp. Live. Non-photosynthetic. Lateral view. Illustrates body shape, cingulum displacement and sulcal list. Large pusule occupies most of cytoplasm. 67 μ long. Probably *D. lenticula* f. *asymmetrica.*

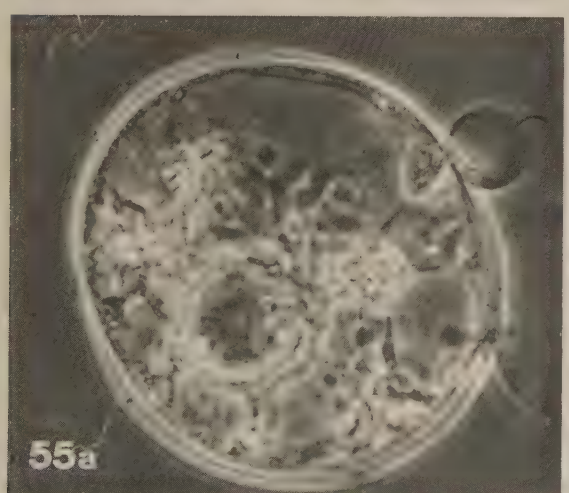
Figure 55. *Dissodinium lunula.* Live. Photosynthetic. Phase contrast. a) Stage I. Cell just beginning to lyse. Note arrangement of protoplasm. 73 μ diameter. b) Stage V. Broad crescent shaped cell (pellicle firm outer margin) with what appears to be encysted protoplasm. Two large vacuoles on either side. 137 μ long. This genus as well as others, produces Gymnodinium-like zoospores.











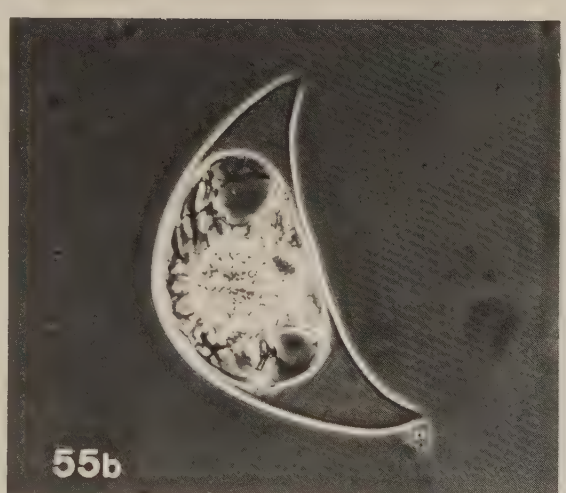


PLATE XVIII

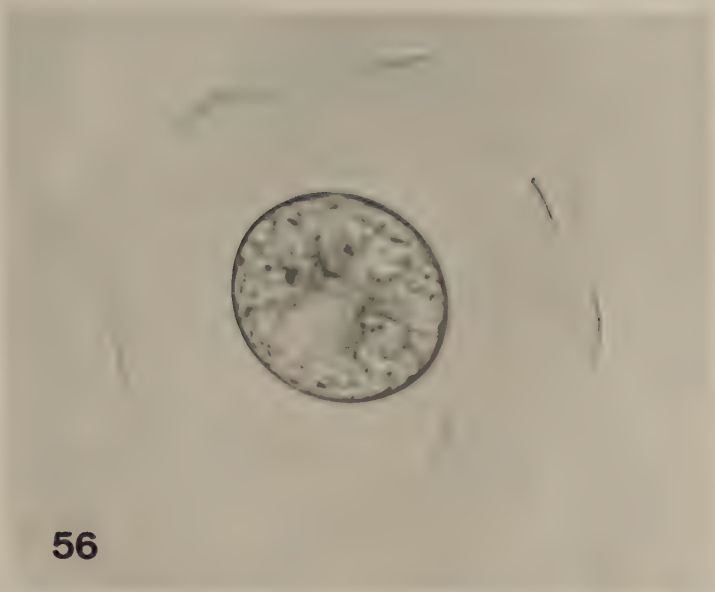
PLATE XIX

Figure 56. *Fragilidium* sp. (?). Live. Photosynthetic. Note arrangement of hyaline plates disassociated from the cyst and retained at a short distance apparently by a mucuous secretion. Cyst – 36 μ X 40 μ.

Figure 57. *Glenodinium* B. Live. Photosynthetic. Chain forming species: note postmedian cingulum. This could be a *Peridinium,* complete plate analyses could not be made. 36 μ long.

Figure 58. *Gonyaulax diacantha.* Live. Photosynthetic. Phase contrast. a) Ventral view. Encysted, cingulum descending, greater than 1X, theca reticulated. Very distinctive small species. 27 μ long. b) Cell compressed dorso-ventrally, photomicrograph shows general outline and antapical spines.

Figure 59. *Gonyaulax diegensis.* Live. Photosynthetic. a) Ventral view. Stout rotund species, cingulum displaced 3X, with slight overhang. Apical process short, not as in *G. digitalis.* Spines winged. 46 μ wide. b) Lateral view. Same specimen showing apical process offset ventrally, little compression, body deep. Theca almost aerolate.



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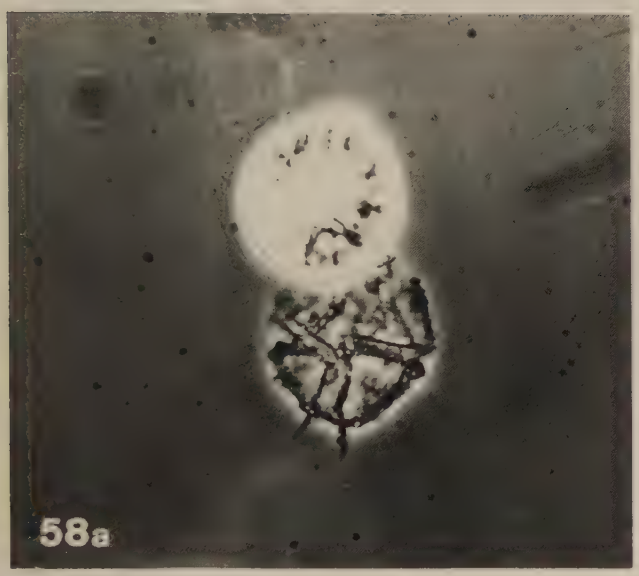
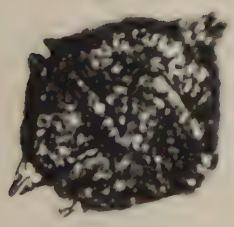
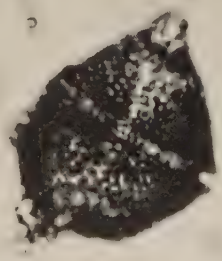


58a

58b



59a



59b

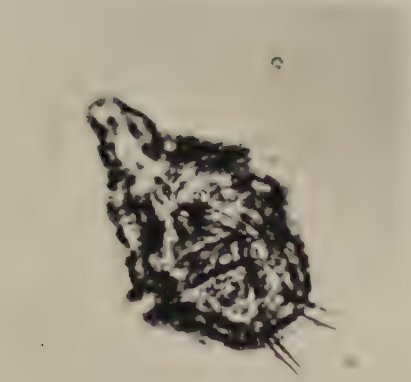
PLATE XIX

PLATE XX

Figure 60. *Gonyaulax digitalis*. Live. Photosynthetic. a) Ventral view. Epitheca attenuated and excavated, exceeds hypotheca. Cingulum descending about 3X with overhang. With or without antapical spines. 55 μ long. b) Lateral view. Same specimen, showing apical process placed ventrally and amount of cingulum displacement.

Figure 61. *Gonyaulax fragilis.* Photosynthetic. a) Live. Ventral view. Illustrates barely detectable theca, descending cingulum (premedian) and rounded hypotheca. No apical process. 45 μ long. b) Preserved. Phase contrast. Semi-lateral view of hypotheca illustrating characteristic longitudinal striae and sulcal area. c) Preserved. Phase contrast. Lateral view of epitheca showing characteristic dorsal extension of apical platelet. 33 μ wide.

Figure 62. *Gonyaulax monilata.* Live. Photosynthetic. a) Catenate species; chains observed up to 72 cells. Compressed anteroposteriorly, cingulum displaced about 1X. 1st apical not in contact with apical platelet. Cytoplasmic continuity between cells. 1st cell about 57 μ wide. b) Ventral view. Enlargement illustrating cell associations and cingulum displacement.



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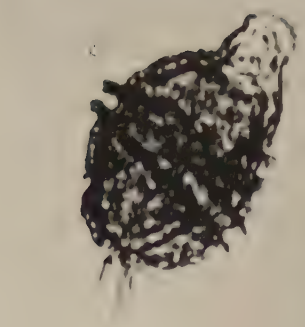

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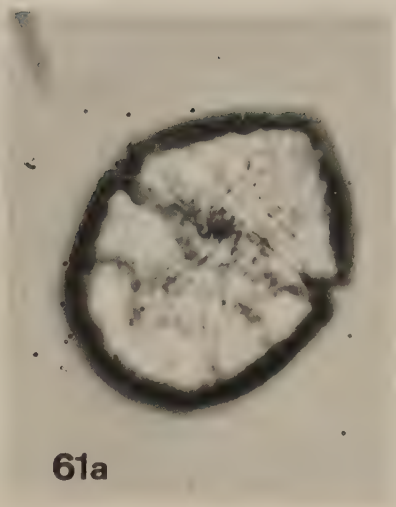

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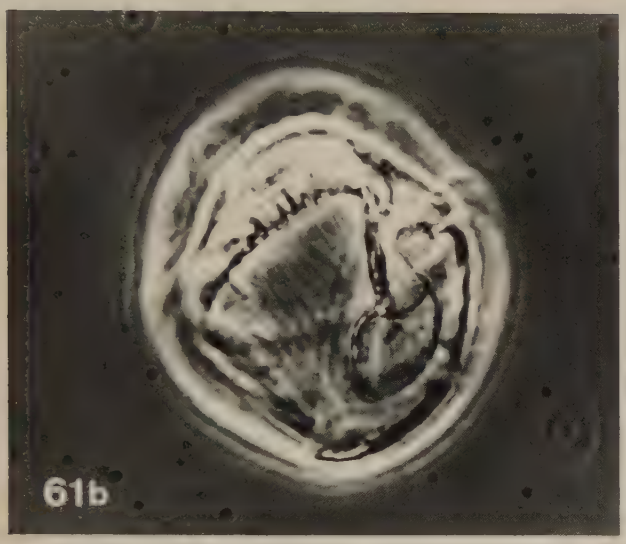

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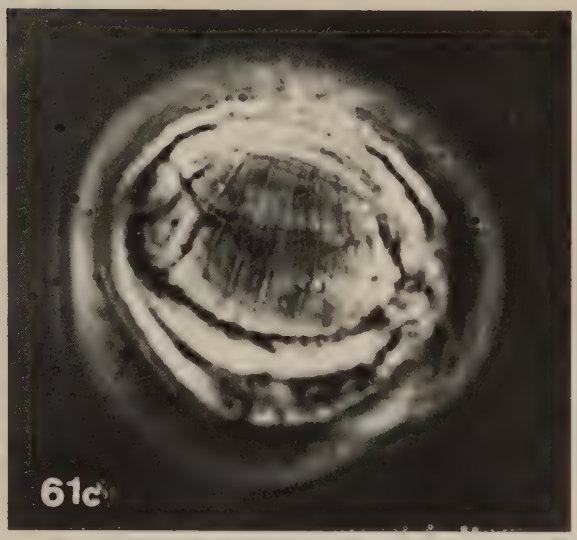

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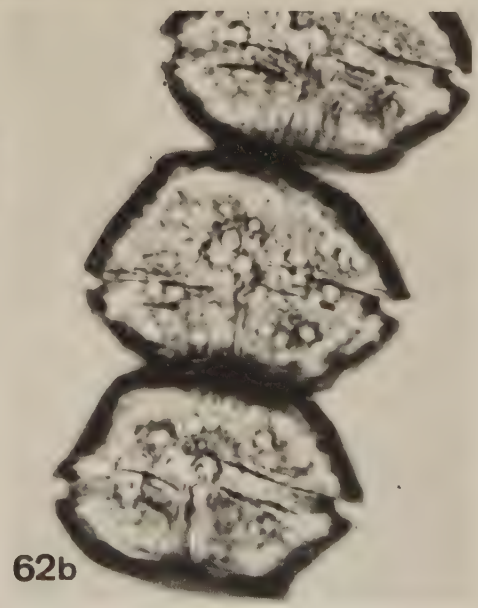


62b

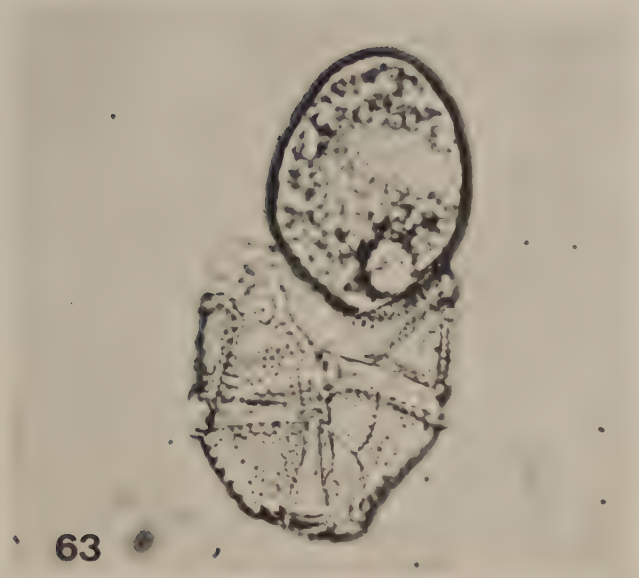
PLATE XX

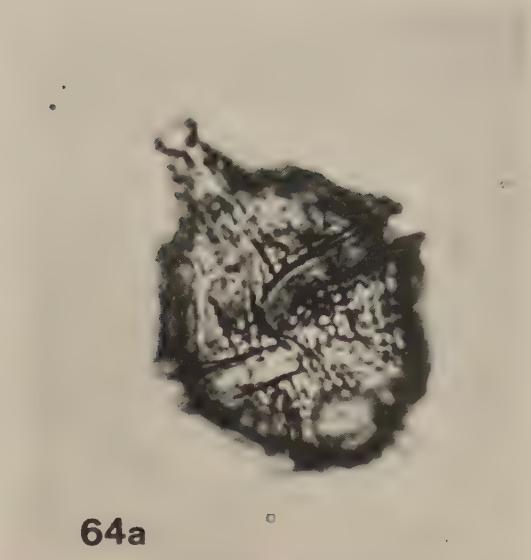
PLATE XXI

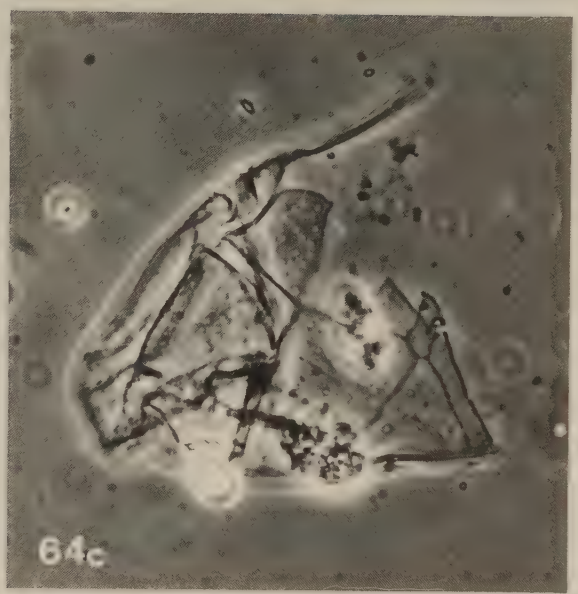
Figure 63. *Gonyaulax polyedra.* Live. Photosynthetic. Ventral view. Cingulum displacement 1X, surface reticulate, cell when intact polygonal shaped. Protoplasm encysted and exuviated. Nucleus premedian.

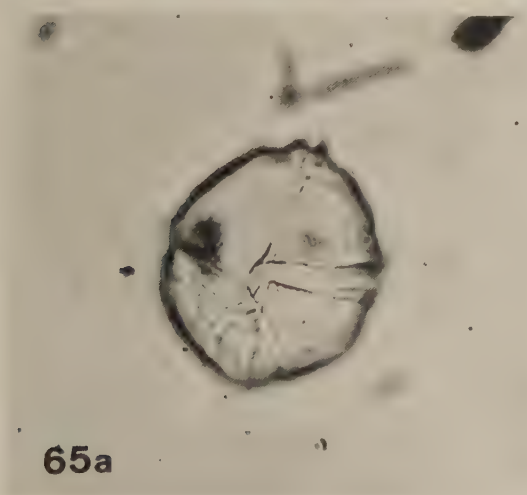
Figure 64. *Gonyaulax polygramma.* Photosynthetic. a) Live. Ventral view. Shows longitudinal striae, descending cingulum 1 1/2X and general body contour. Theca heavily sculptured. 48 μ wide. b) Preserved. Phase contrast. Young stage in thecal development, Plates 1' and 4' at apex. Theca without pores, reticulations, or striae; only sutures present. 57 μ long. c) Disassociated. Phase contrast. Later stage in thecal maturation showing pores (with raised ridges). Striae are formed between 2 linear rows of pores.

Figure 65. *Gonyaulax turbynei.* Photosynthetic. a) Preserved. Ventral view. Cell with slightly postmedian cingulum, short apical process and fine striae and reticulations. No antapical spines. b) Disassociated. Phase contrast. Ventral view. Illustrates striae, reticulations and newly found 4' and 1a. Plate 4' – 11 μ long.









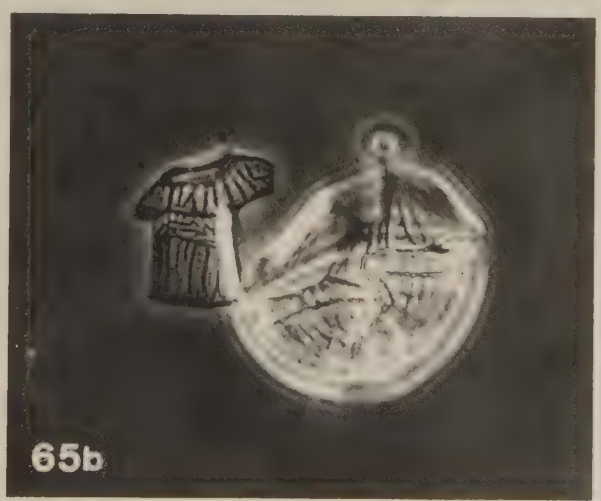


PLATE XXI

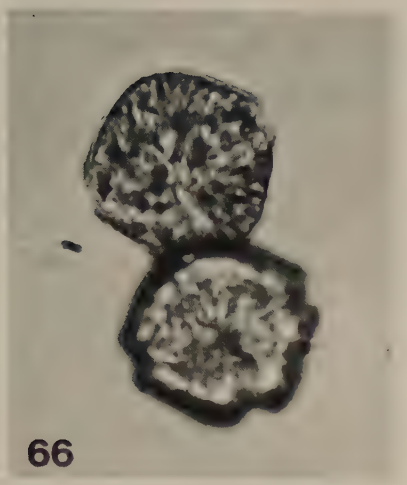
PLATE XXII

Figure 66. *Gonyaulax* sp. Live. Photosynthetic. Ventral view. Catenate species, resembling *G. tamerensis* f. *excavata.* Cingulum displaced about 1 1/2X 1st apical notched, in contact with closing platelet.

Figure 67. *Gymnodinium breve.* Live. Photosynthetic. Ventral view. One of the more common forms of this species. Apical process notched. Sulcus invades epicone. 24 μ wide. Forms exist with heavy and thin pellicles.

Figure 68. *Gymnodinium coeruleum.* Live. Non-photosynthetic. a) Lateral view. Large bluish-green (sometimes pink) species with thick ridged pellicle. Occasionally found in preserved material in excellent condition (identifiable). More ridges on hypocone than epicone. 105 μ long. b) Dividing cell showing longitudinal oblique fission characteristic of most dinoflagellates. 123 μ long.

Figure 69. *Gymnodinium splendens.* Live. Photosynthetic. a) Semi-lateral view. Cell with premedian cingulum, bilobed hypocone. Cell depth not typical. 51 μ long. b) Bilobed hypocone and conical epicone characteristic, cingulum median to slightly premedian. Nucleus centrally located, radiating chloroplasts. 35 μ wide. c) Ventral view. Most common form encountered with helmet-shaped epicone and bilobed hypocone, displaced cingulum and central nucleus. This form identified as *G. nelsonii* by some workers. d) Common hypoconal aberration, extremely bilobed. Sulcus does not invade epicone in any of the forms.



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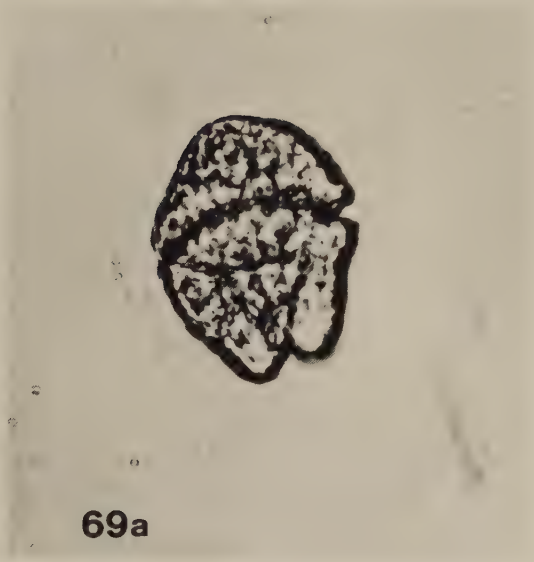

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PLATE XXII

PLATE XXIII

Figure 70. *Gymnodinium* E. Live. Photosynthetic. Phase contrast. Ventral view. Note sulcal extension on epicone and cingulum displacement. Small species, compressed dorso-ventrally. Approximately 25 μ long.

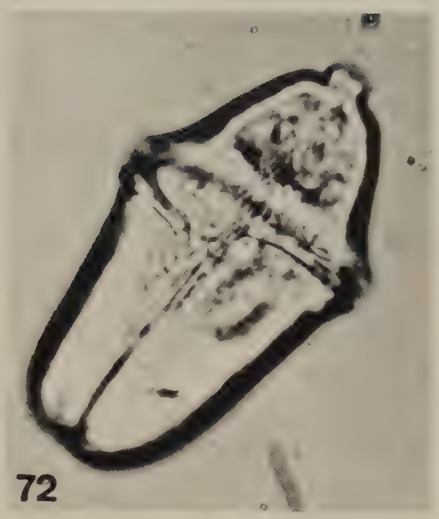
Figure 71. *Gymnodinium* I. Live. Non-photosynthetic. Ventral view. Similar to *G. coeruleum* (ridged) but with less cingulum displacement. Cingular area scalloped, which could have resulted from phagocytic activity. 102 μ long.

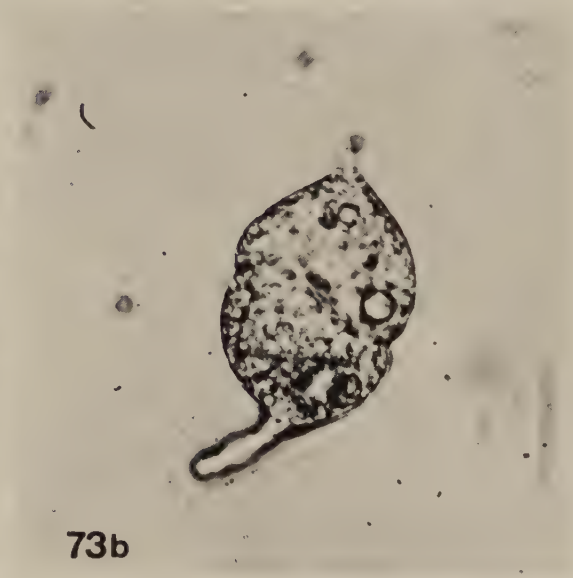
Figure 72. *Gymnodinium* J. Live. Non-photosynthetic. Ventral view. Cingulum displacement less than 1/5th body length. Pellicle striated, epicone with mamillate process. Sulcus invading epicone and notching hypocone. 90 μ long.

Figure 73. *Gyrodinium falcatum.* Live. Photosynthetic. a) Lateral view. Cingulum displaced greater than 1/5th body length. Displacement may appear less because of the unusual attenuation of specimen. 90 μ long. b) Encysted cell with attenuated apices. Nucleus anterior.

Figure 74. *Gyrodinium fissum.* Live. Photosynthetic. Ventral view. Cingulum postmedian, epicone exceeds hypocone. Cingular displacement inverted (specimen focused through), about 4X with distinct cingulum overhang. Approximately 50 μ long.

Figure 75. *Gyrodinium* F. Live. Photosynthetic. Cell cigar-shaped, epicone short, hypocone attenuated. Nucleus prominent, located anteriorly. 48 μ wide.





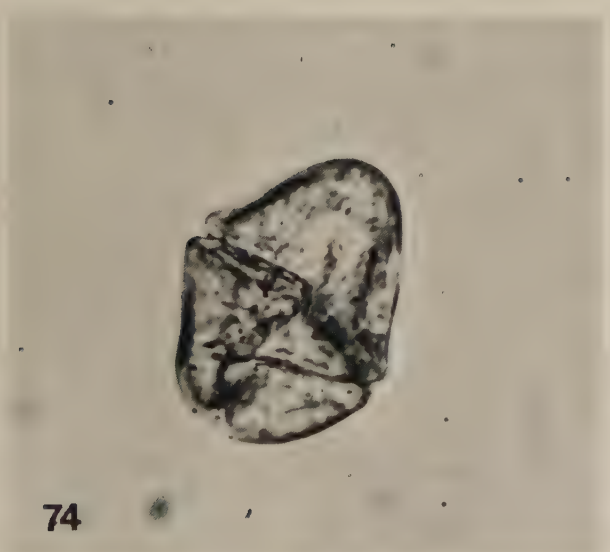
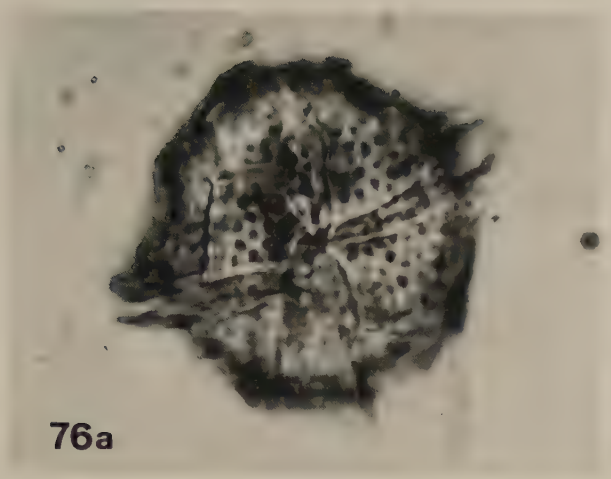


PLATE XXIII

PLATE XXIV

Figure 76. *Heteraulacus acuminatus.* Photosynthetic. a) Live. Ventral view. Cingulum descending, about 1X. Surface aerolate with characteristic angular thecal appearance. 56 μ long. b) Disassociated. Epithecal and hypothecal views with clearly defined plate series. c and d) Apical and dorsal views of one daughter cell showing fission lines and the distinction between mature and developing plates. 67 μ wide. e and f) Other daughter product illustrating recent division and the rugose aerolate apical plate. 64 μ wide.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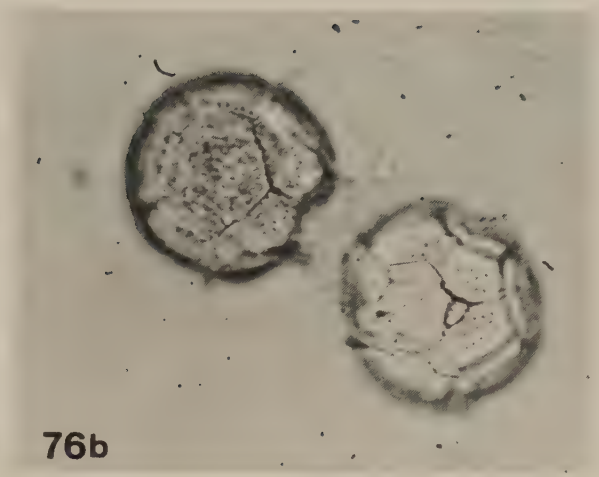
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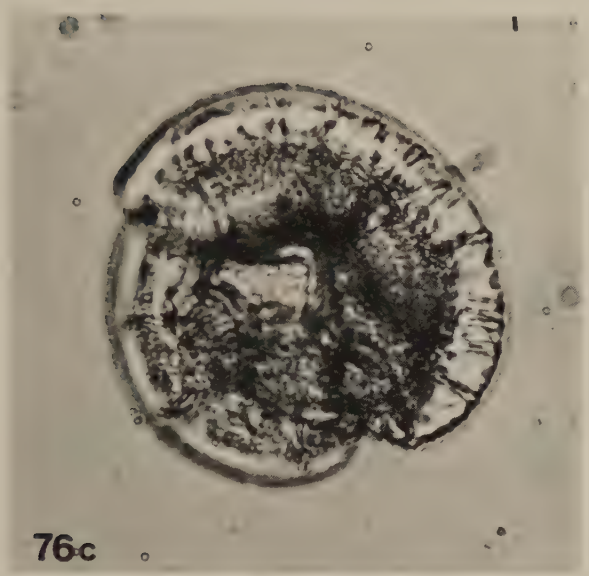
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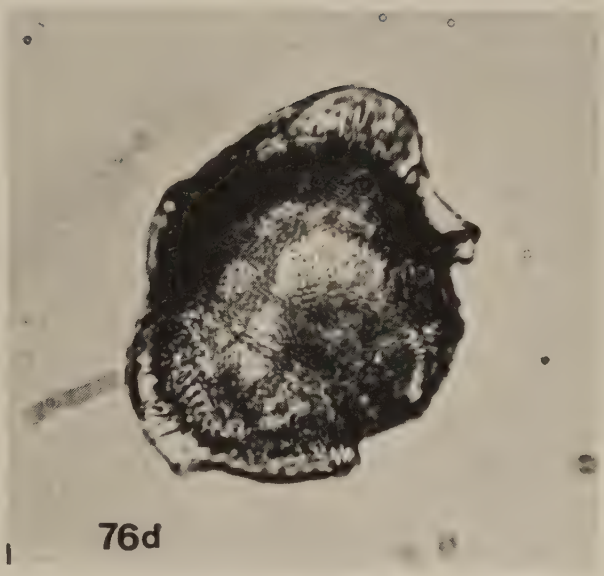
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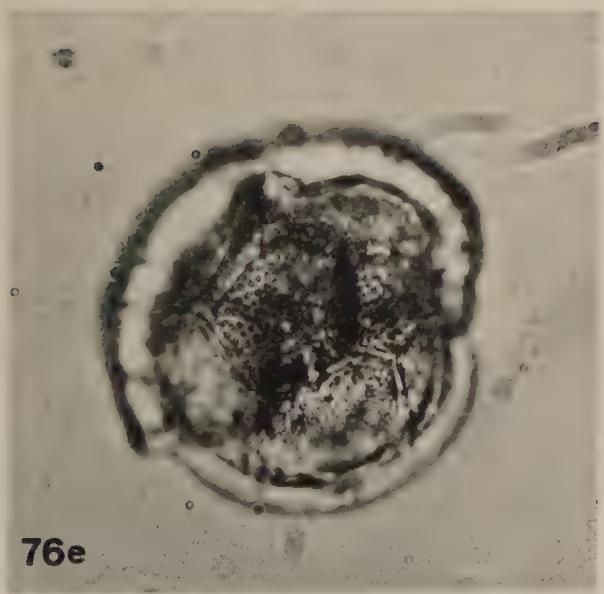
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PLATE XXIV

PLATE XXV

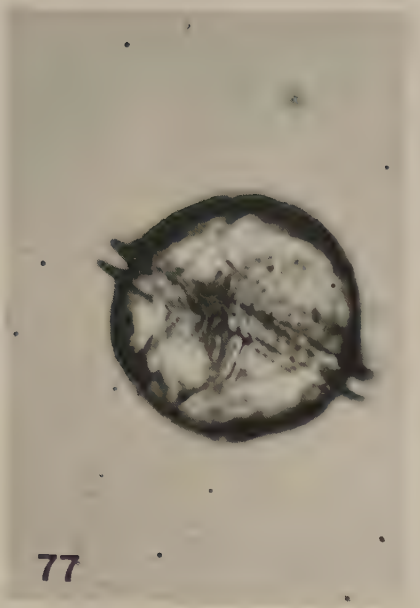
Figure 77. *Heteraulacus sphericus.* Live. Photosynthetic. Ventral view. Shape globular, no angles, cingulum displaced about 1X, wide sulcal area.

Figure 78. *Kofoidinium pavillardii.* Live. Non-photosynthetic. a) Lateral view. Large species, small epicone, expanded hypocone, cingulum premedian as in *Amphidinium.* Protoplasm radiating from central core. 165 μ wide. b) Phase contrast. Developmental stage of *Kofoidinium* sp., possibly *K. pavillardii.* Compressed cell with high cingulum, enclosed in theca-like envelope.

Figure 79. *Ornithocercus magnificus.* Non-photosynthetic. a) Live. Lateral view. Phase contrast accentuates R_1 with spur but less developed ribs. Body – 45 μ wide. b) Preserved. Lateral view. Widely lobed sulcal list extending onto antapex, 1st rib (R_1) typically L shaped with fission rib above. Body – 64 μ long.

Figure 80. *Ornithocercus steinii.* Live. Non-photosynthetic. Lateral view. Left sulcal list lobed, each lobe with supporting rib. Body – 70 μ wide.

Figure 81. *Ornithocercus thumii.* Crushed. Non-photosynthetic. Lateral view. Note V shaped sulcal list (left) compared to the quadradentate sulcal list of *O. steinii.* Epitheca short, barely discernible, with funnel-shaped cingular lists. Body – 66 μ wide.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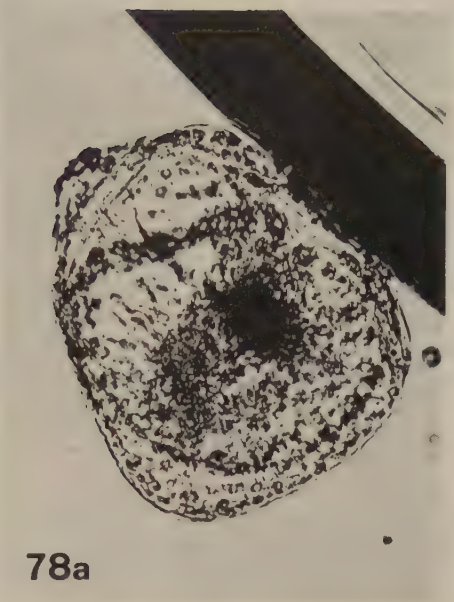
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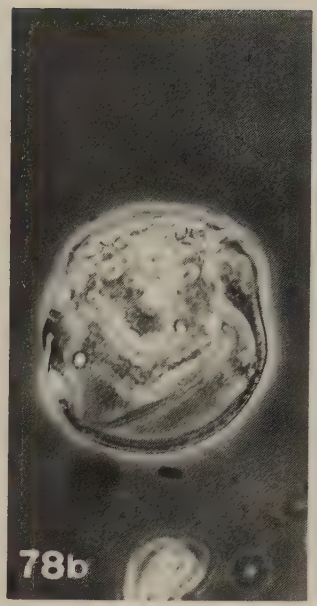
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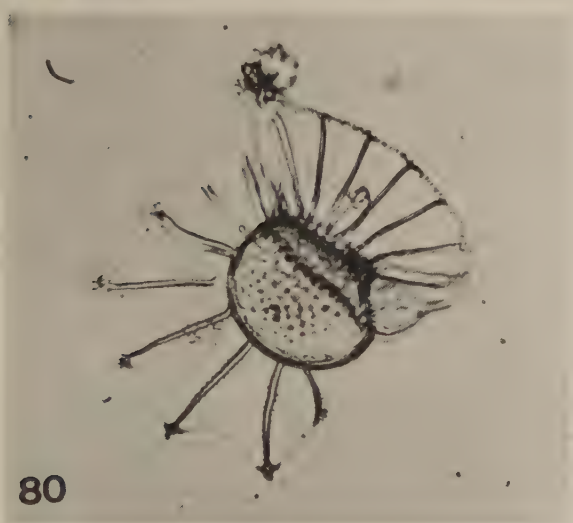
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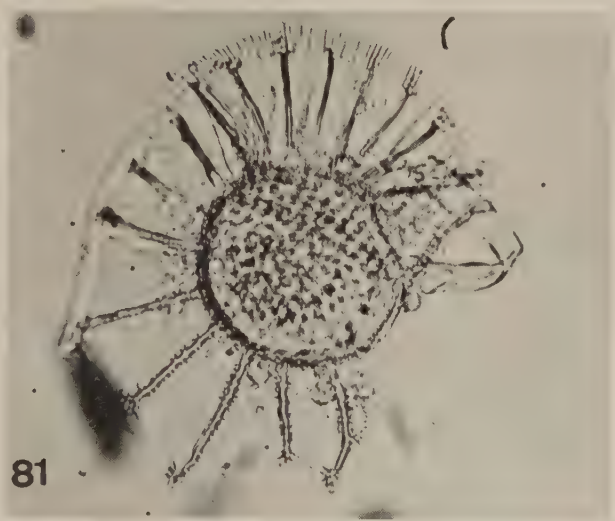
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PLATE XXV

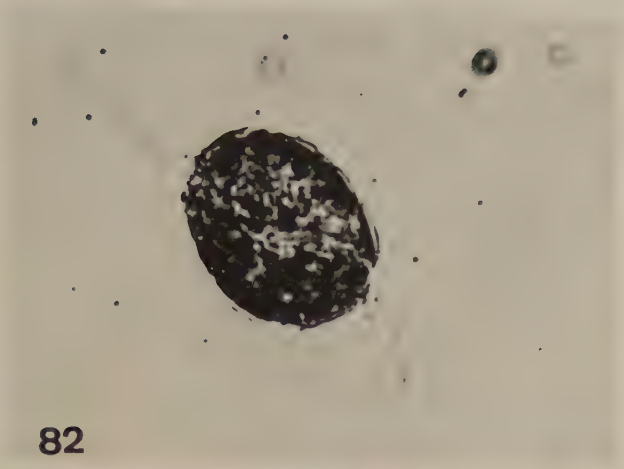
PLATE XXVI

Figure 82. *Coolia (=Ostreopsis) monotis.* Live. Photosynthetic. Lateral view. Illustrates oblique axis and cingulum orientation. Depth along cingulum – 31 μ.

Figure 83. *Oxyhrris marina.* Live. Non-photosynthetic. Phase contrast. Small specimen with indistinct sulcal and cingular areas. This species has often been observed in 2 size categories, one form around 30 μ long and the other form almost twice as large. It could be that there are two different species involved.

Figure 84. *Oxytoxum elegans*. Disassociated. Photosynthetic. Phase contrast. Plates illustrate striae pattern characteristic of several *Oxytoxum* (hypotheca). Intact specimen – 49 μ wide.

Figure 85. *Oxytoxum gigas.* Photosynthetic. a) Live. Lateral view. Very broad specimen, cell beginning to break apart. Nucleus posterior, central pigment mass. 88 μ wide. b) Disassociated. Phase contrast. Separated epithecal plates showing hook-and-eye arrangement of longitudinal striae. c) Crushed. Phase contrast. Theca showing cingulum displacement (greater than 4X) and longitudinal striae with hook-and-eye type pattern.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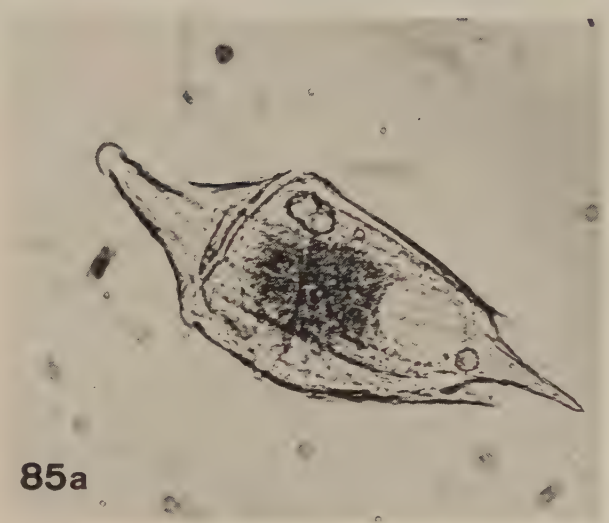
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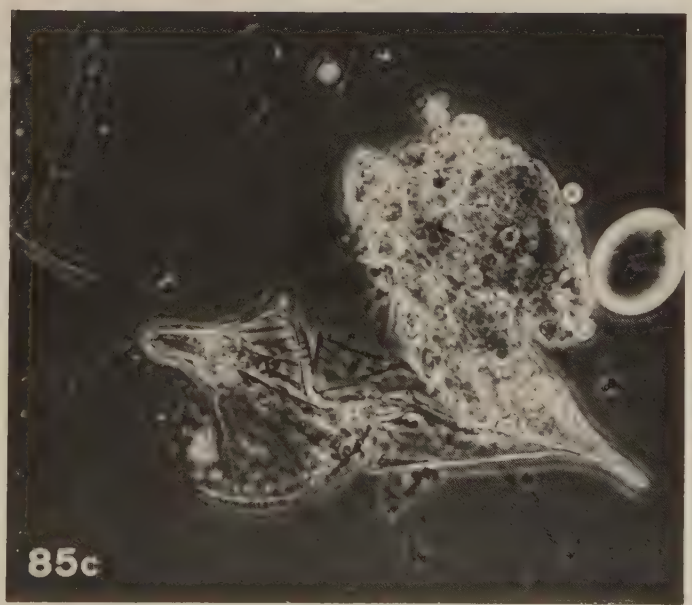
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PLATE XXVI

PLATE XXVII

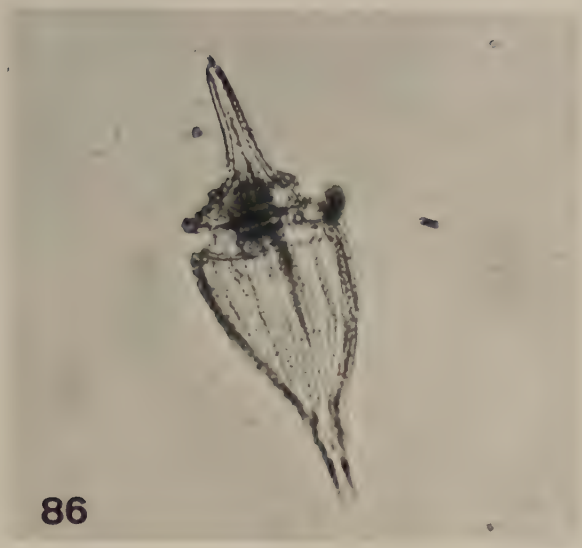
Figure 86. *Oxytoxum milneri.* Preserved. Lateral view. Epitheca and hypotheca characteristic, apical process usually with small spine, hypotheca with broader solid point. Approximately 100 μ long.

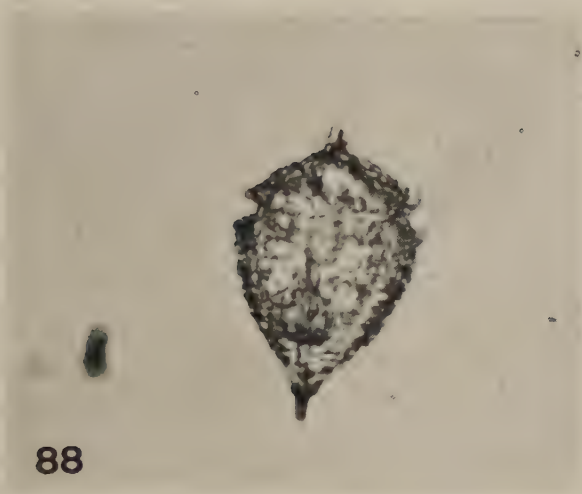
Figure 87. *Oxytoxum scolopax.* Live. Photosynthetic. Lateral view. Cell with attenuated and pointed apices, epitheca almost lanceolate. 77 μ long.

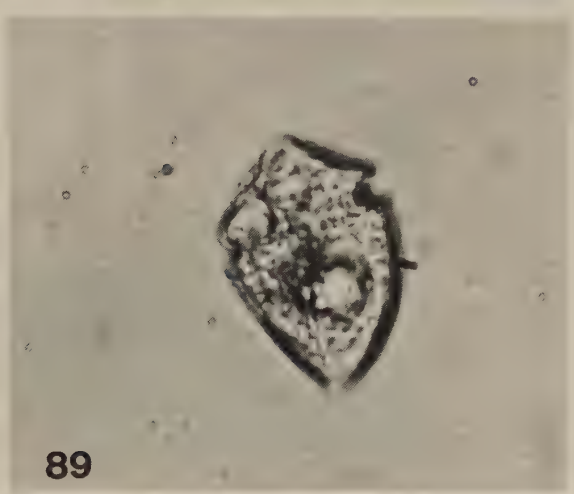
Figure 88. *Oxytoxum tesselatum.* Live. Photosynthetic. Cell top-shaped, apices with short pointed projections.55 μ long.

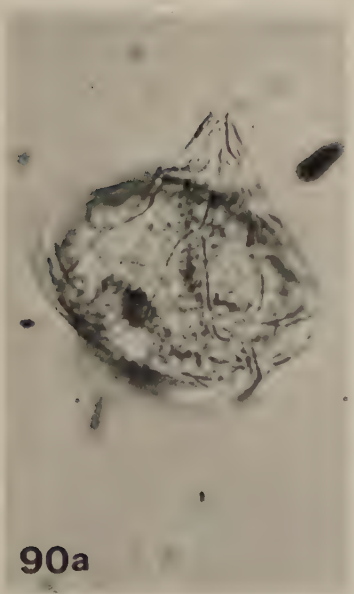
Figure 89. *Oxytoxum* sp. Live. Photosynthetic. Semi-lateral view. Cingulum descending, hypotheca pointed and curved ventrally. 71 μ long.

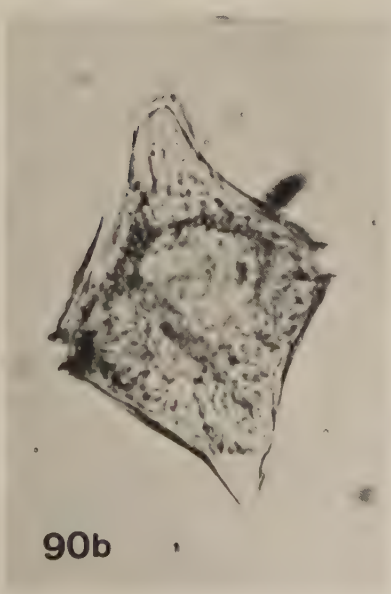
Figure 90. *Peridinium abei.* Preserved. Non-photosynthetic. a) Semi-ventral view of epitheca with displaced cingulum, about 2X. Acutely biconical cell. 108 μ long. b) Same specimen, lateral view. c) Same specimen, ventral hypotheca showing sulcal area, cingulum displacement and antapex.











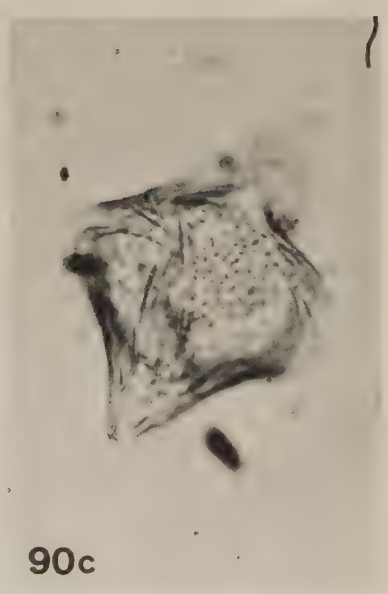


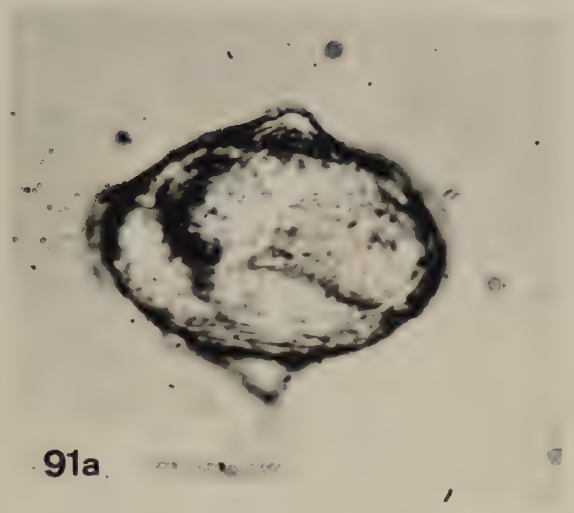
PLATE XXVII

PLATE XXVIII

Figure 91. *Peridinium biconicum.* Crushed. Non-photosynthetic. a) Dorsal view of epitheca, cell broadly biconical. b) same specimen showing sulcus and antapex development. Approximately 95 μ wide.

Figure 92. *Peridinium brochii.* Live. This heavily pigmented specimen is not typical. 94 μ long.

Figure 93. *Peridinium claudicans.* Live. Non-photosynthetic. a) Oblongum group, ortho, quadra (sometimes penta). Ventral view. Cingulum descending, greater than 1X. Typical specimens usually inflated and delicate. Large pusule on right side. This specimen closer to Lebour's (1925) description. 99 μ long. b) Similar to *P. oblongum* but without apical development and ventro-dorsal compression. Typical specimens of this species encountered resembled that illustrated by Schiller (1937) after Dangeard.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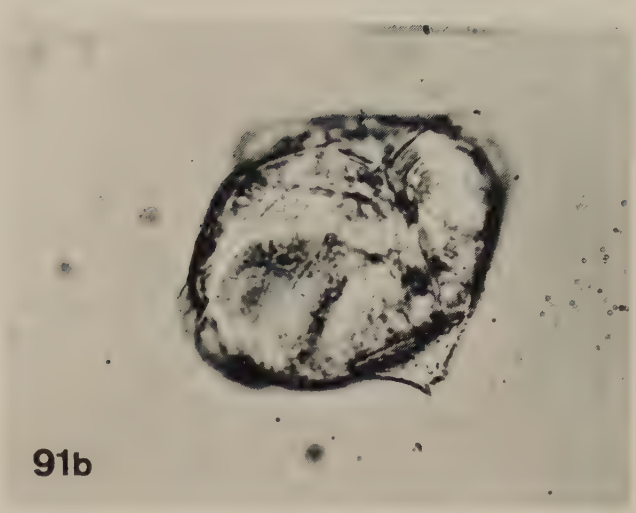
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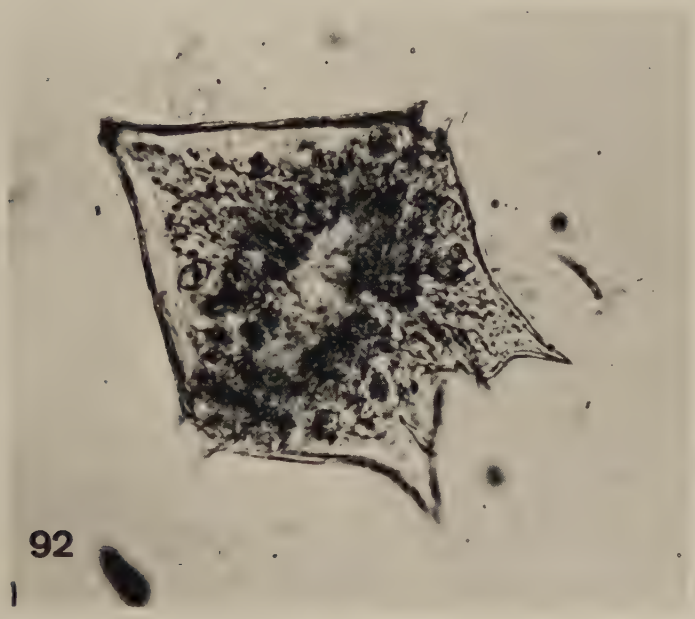
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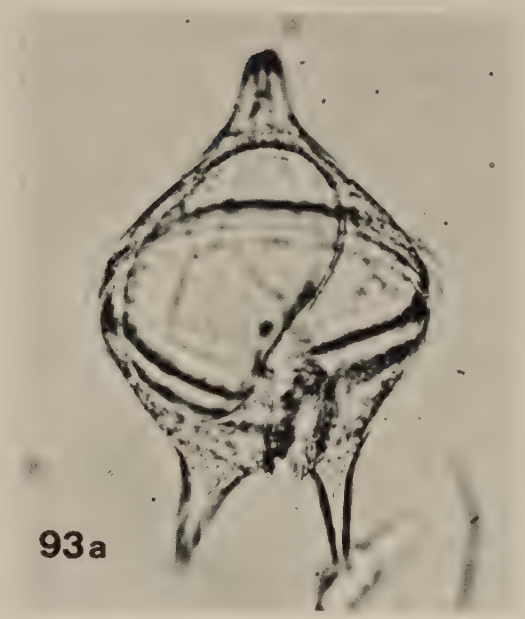
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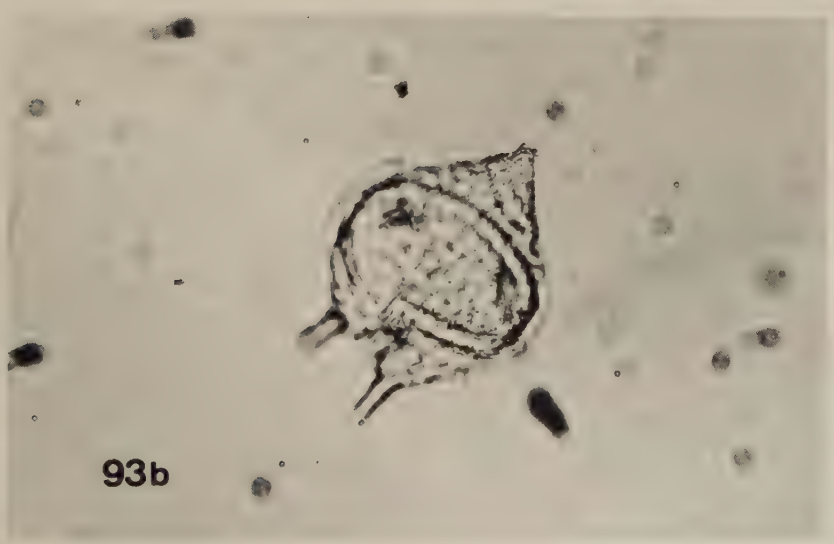

93b

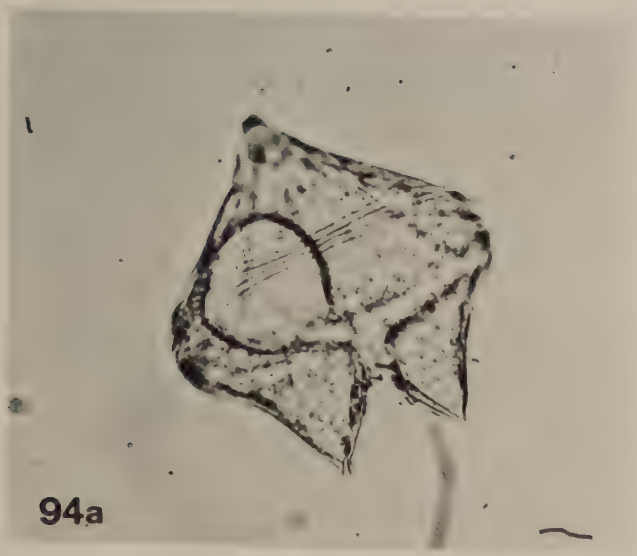
PLATE XXVIII

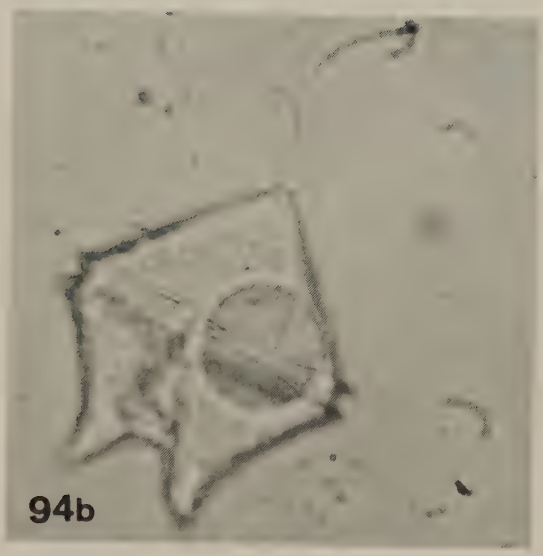
PLATE XXIX

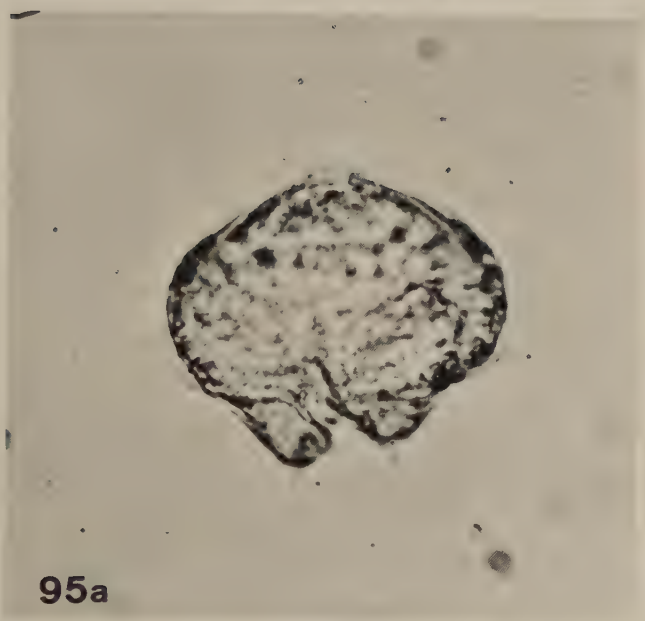
Figure 94. *Peridinium conicum.* Live. Non-photosynthetic. a) Dorsal view. Broad cell illustrating typical antapical and apical horn development. b) Dorsal view showing hexa *2a* and large pusule on right side. Approximately 70 μ long.

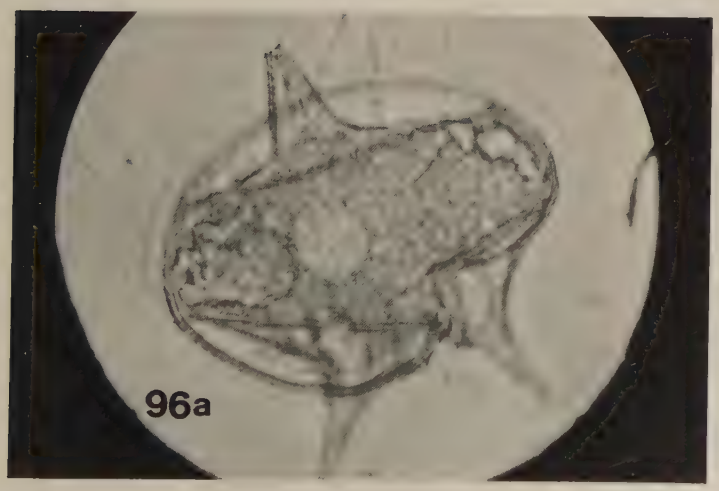
Figure 95. *Peridinium crassipes.* Live. Non-photosynthetic. a) Ventral view. Specimen recently excysted with weak theca, cingulum slightly displaced. 56 μ long. b) Phase contrast. Shows characteristic epithecal outline (which is similar to *P. depressum*), surface reticulations and typical apical horn development.

Figure 96. *Peridinium depressum.* Preserved. Non-photosynthetic. a) Semi-ventral view. Large cell indicating depth of body and large antapical horns. b) Phase contrast. Ortho 1st apical, theca reticulated. Cell rather deep and large with prominent divergent antapical horns. Approximately 130 μ wide.









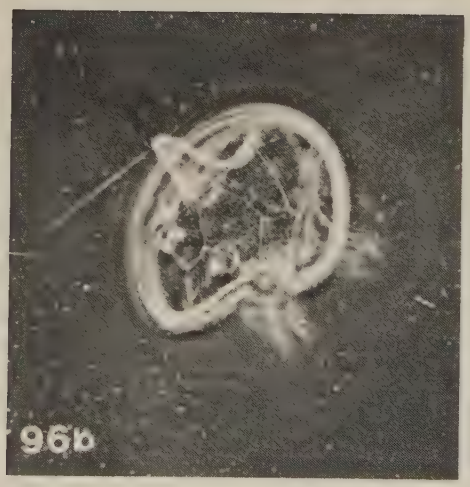


PLATE XXIX

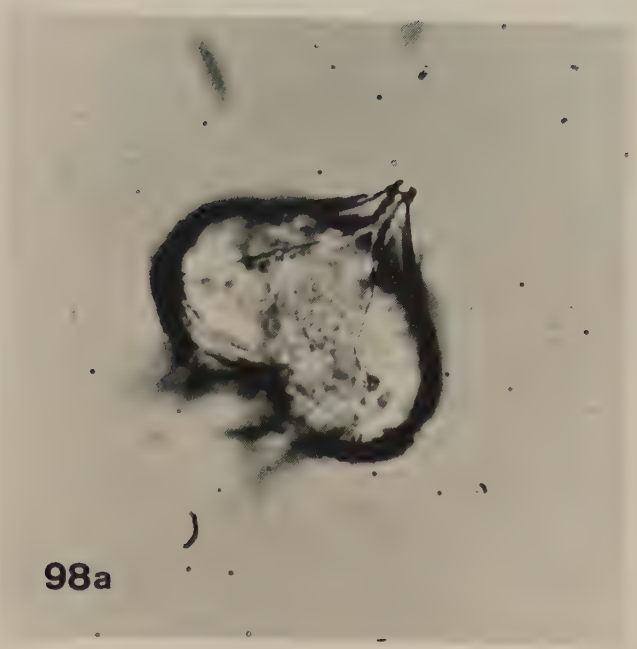
PLATE XXX

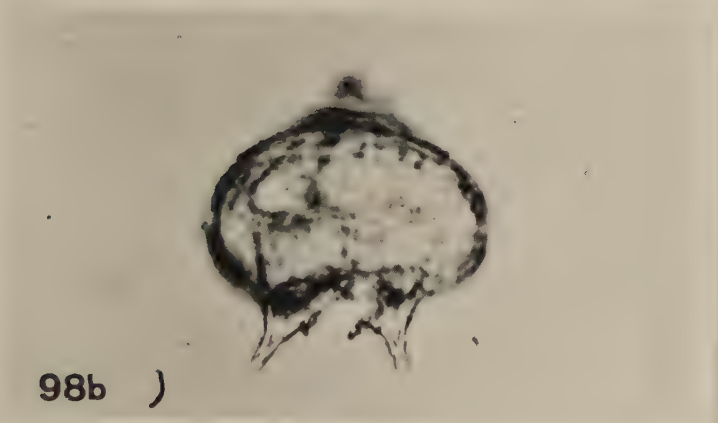
Figure 97. *Peridinium longipes.* Live. Non-photosynthetic. Ventral view. Ascending cingulum with lists supported by spines. Winged solid antapical horns and large apical horn. 66 μ wide.

Figure 98. *Peridinium divergens.* Live. Non-photosynthetic. a) Ventral view of epitheca showing 5 sided apical plate (meta). Cingulum not displaced. 48 μ wide. b) Dorsal view of hypotheca, same specimen, demonstrating the typical antapical horns. Large 3''' dominates view.

Figure 99. *Peridinium elegans.* Live. Non-photosynthetic. Compare to f. *granulata.* Cingular area not as compressed, antapical horns not directed outwardly. Theca reticulate. 175 μ long.

Figure 100. *Peridinium elegans* f. *granulata.* Live. Non-photosynthetic. a) Ventral view. Large species, attenuated apex, compressed cingular area, attenuated antapices. Meta, quadra. Antapicals divergent and reticulated (appears spinous). Theca reticulate. 179 μ long. b) Dorsal view showing divergent ornate antapical horns. Compare size of adjacent *Prorocentrum.*





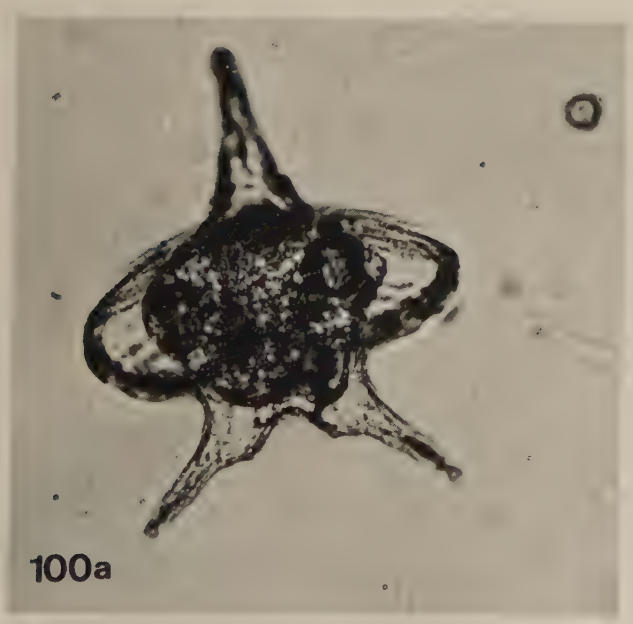


PLATE XXX

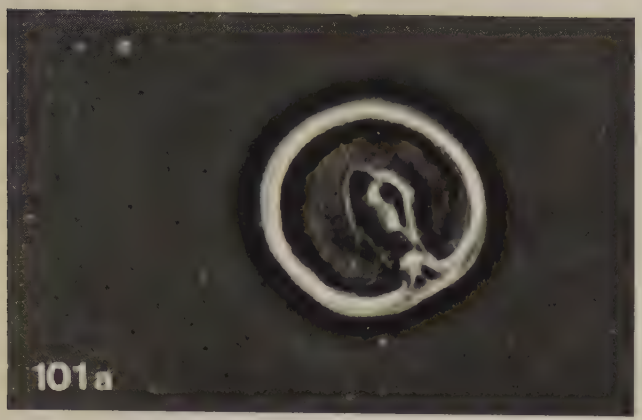
PLATE XXXI

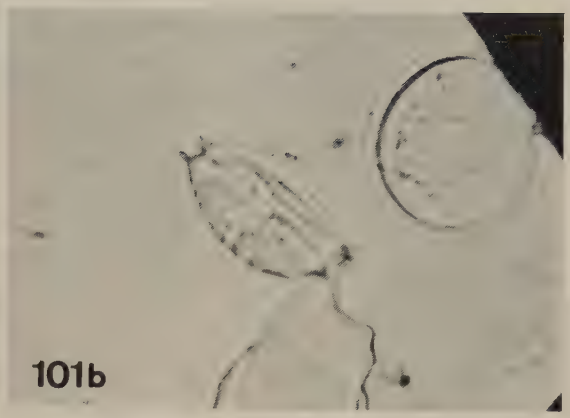
Figure 101. *Peridinium excentricum.* Preserved. Non-photosynthetic. a) Phase contrast. Antapical view. Shows large 2'''' and characteristic sulcal area with heavy beak-shaped intermediate thickening. Fringe represents spined cingular lists. 62 μ wide. b) Ventral view. Illustrates anterio-posterior compression, typical cells usually more compressed. Note antapical protrusion on left side.

Figure 102. *Peridinium fatulipes.* Preserved. Non-photosynthetic. a) Dorsal view. Large species, compressed precingular area, epitheca attenuated. Hypothecal horns similar to *P. elegans* f. *granulata* except for the cross bar adjoining divergent horns. Theca reticulate. 210 μ long. b) Ventral view. Compression of cingular area more evident.

Figure 103. *Peridinium globulus* f. *quarnerense.* Live. Non-photosynthetic. Lateral view. Globular cell with widely displaced cingulum (ascending), short antapical spines and large central pusule. Approximately 70 μ long.

Figure 104. *Peridinium grande.* Live. Non-photosynthetic. Meta, quadra. Ventral view. Cingulum slightly descending, theca reticulate. Compare to *P. elegans.* 130 μ wide.





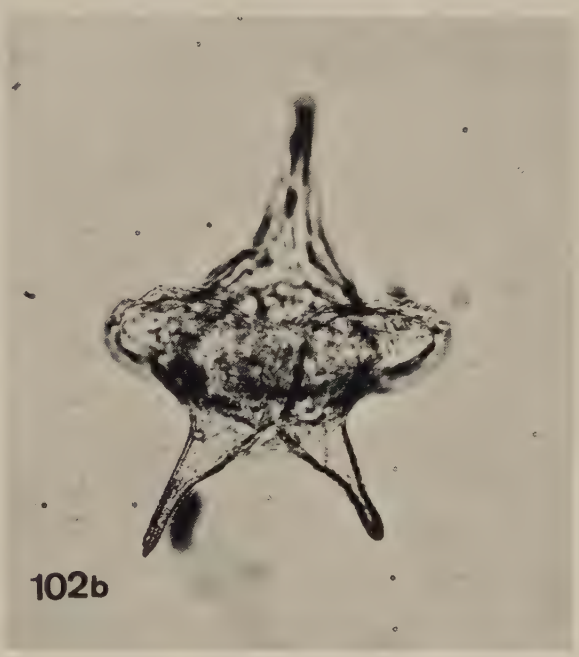


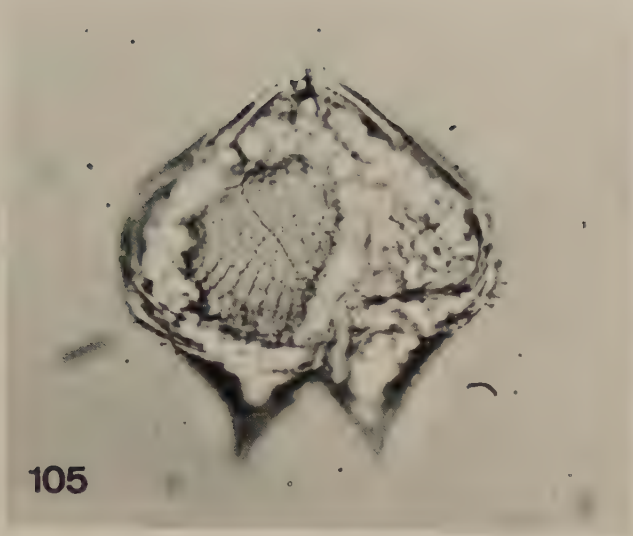
PLATE XXXI

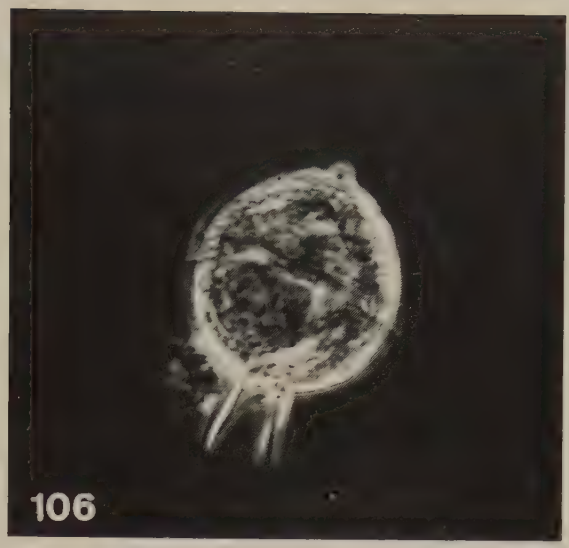
PLATE XXXII

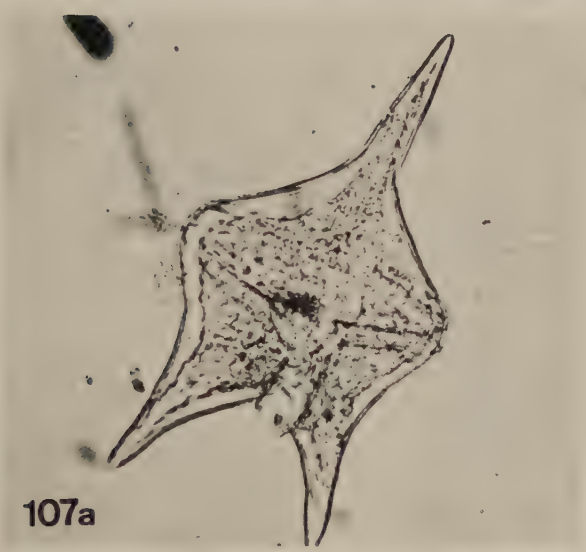
Figure 105. *Peridinium leonis* (?). Live. Non-photosynthetic. Ortho. Ventral view. Epitheca finely reticulate. Cingulum displaced about 1X. Cytoplasm with numerous oil globules and one large pusule. 67 μ wide.

Figure 106. *Peridinium nipponicum.* Preserved. Non-photosynthetic. Phase contrast. Dorsal view. Similar to *P. pellucidum* but not as broad and without wide cingular lists and flared apical horn. Mamillate process apically. 38 μ wide excluding lists.

Figure 107. *Peridinium oblongum.* Non-photosynthetic. a) Preserved. Ortho, quadra. Ventral view. Long apical and antapical horns characterize this variable species, 133 μ long. b) Preserved. Compare to a and c for contour variability and attenuation of horns. 74 μ wide. c) Live. Ventral view. Cingulum displacement about 1X. 117 μ long. The cell to the left is *Gonyaulax polygramma.* d) Preserved. Lateral view. Note extreme ventro-dorsal compression and apical process. 63 μ wide.







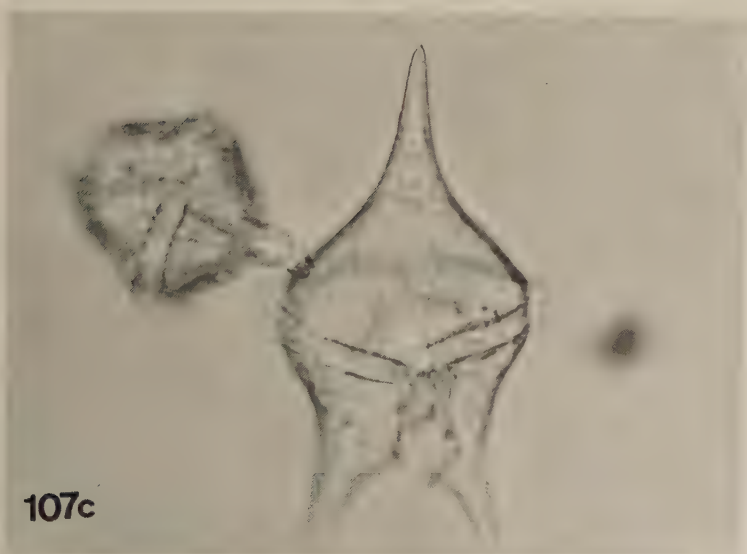


PLATE XXXII

PLATE XXXIII

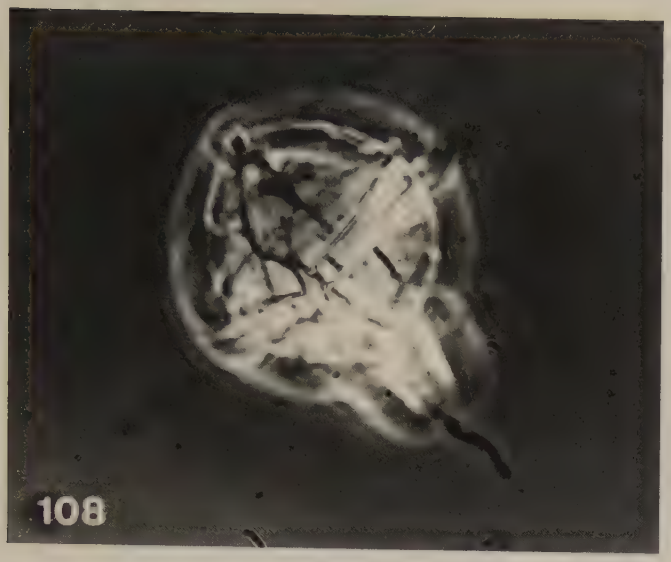
Figure 108. *Peridinium ovum.* Live. Non-photosynthetic. Phase contrast. Para, hexa. Ventral view. Cingulum descending about 1X. Ovoid with short apical process. Two long winged antapical spines. 53 μ long.

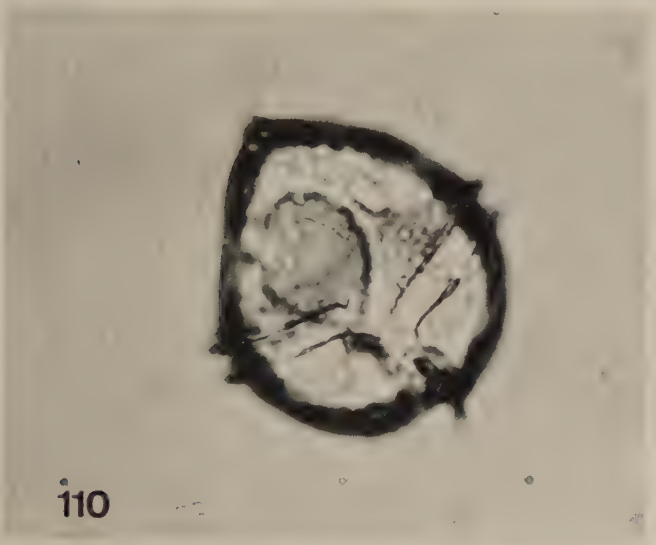
Figure 109. *Peridinium pallidum.* Live. Non-photosynthetic. Phase contrast. Ventral view. Ovoid, epitheca exceeds hypotheca, cingulum ascending, 1X. Conical epitheca with short apical process. 54 μ long.

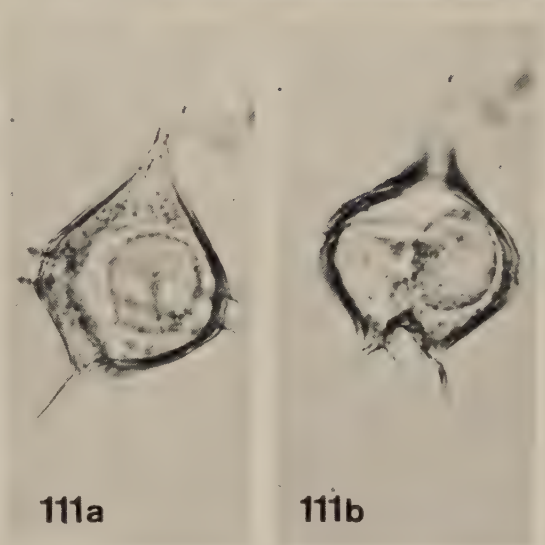
Figure 110. *Peridinium pallidum* var. *schilleri* (?). Live. Non-photosynthetic. Ventral view. Cell pear-shaped, epitheca exceeds hypotheca, cingulum ascending about 1X. 57 μ long.

Figure 111. *Peridinium pellucidum.* Live. Non-photosynthetic. a) Lateral view. Cell with wide cingular lists and apical horn. Cell as deep as wide, epitheca exceeds hypotheca. 40 μ wide. b) Dorsal view. Same specimen showing spine-like antapical horns of hypotheca.

Figure 112. *Peridinium pentagonum.* Live. Non-photosynthetic. a) Broad species, pentagonal, ortho first apical. Cingulum displaced greater than 1X, sulcus J shaped, not extending to antapex. 112 μ wide. b) Same specimen, antapical view showing body depth and contour, body not drastically compressed dorso-ventrally as in the variety.







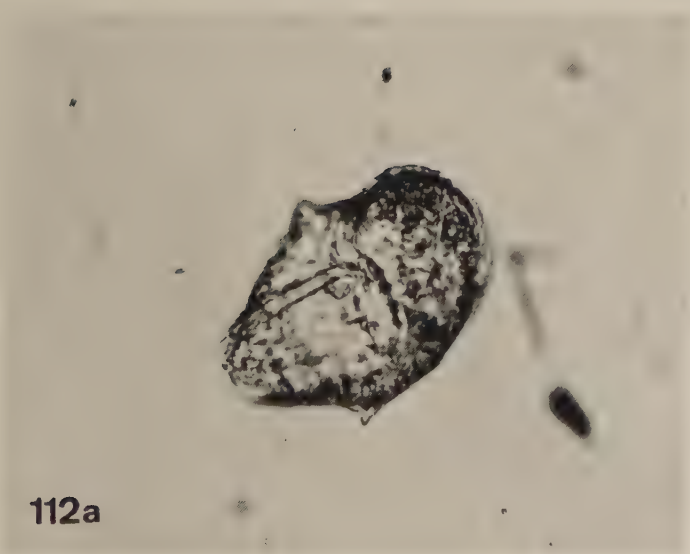


PLATE XXXIII

PLATE XXXIV

Figure 113. *Peridinium pentagonum* var. *latissimum.* Crushed. Non-photosynthetic. Ventral view. Very broad specimen, roof-like epitheca with characteristic curvature to cingulum. 126 μ wide.

Figure 114. *Peridinium spiniferum.* Live. Non-photosynthetic. a) Ventral view. Like *P. divergens* in general body contour, but not in plate configuration (hexa). Cingulum ascending, 1X. Theca with prominent knobs distributed over entire surface. 64 μ wide. b) Lateral view, same specimen. Note depth of cell and cingulum.

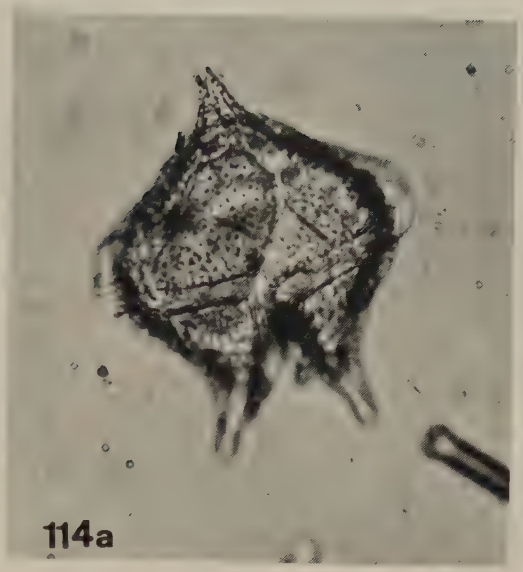
Figure 115. *Peridinium subinerme.* Live. Non-photosynthetic. Ortho, hexa. Ventral view. Excavated conical epitheca. Cingulum not displaced. Biconical hypotheca. 41 μ wide.

Figure 116. *Peridinium subinerme* var. *punctulatum.* Live. Non-photosynthetic. Ventral view. Broadly conical epitheca and hypotheca, cingulum not displaced. Theca punctate, occasionally reticulate. 50 μ long.

Figure 117. *Peridinium trochoideum* (?). Disassociated. Photosynthetic. Phase contrast. Ortho, hexa. a) Ventral view. Epitheca separated from hypotheca and cingulum. Cingulum descending, 1/2X. Epitheca – 14 μ long. b) Dorsal view. Note hexa 2*a* on right dorsal epitheca.

Figure 118. *Peridinium tuba* (?). Live. Non-photosynthetic. Apical horn pronounced, spherical body with long antapical spines. Cingulum ascending. Nucleus large and posterior. Plates difficult to discern. 31 μ long.

113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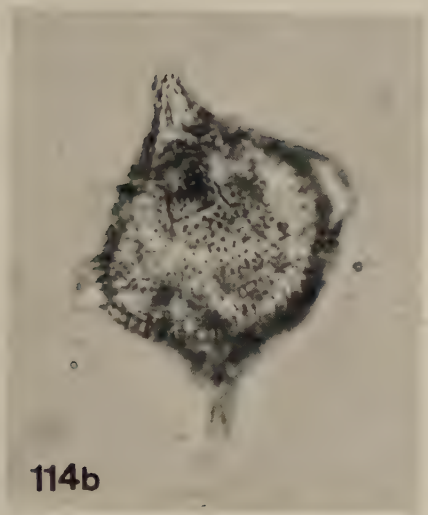
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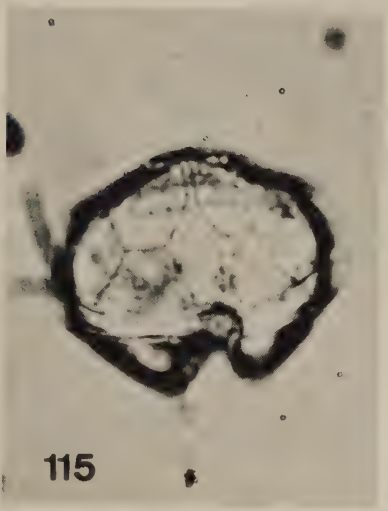
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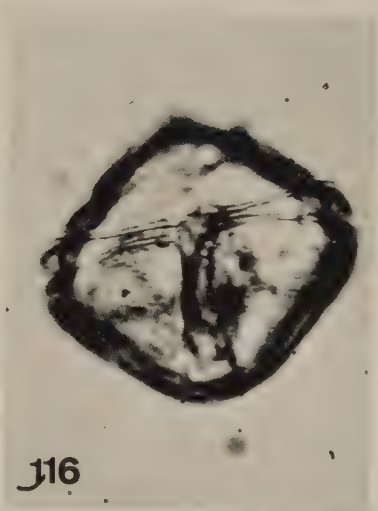
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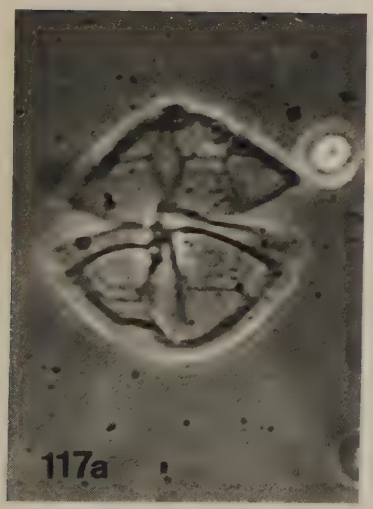
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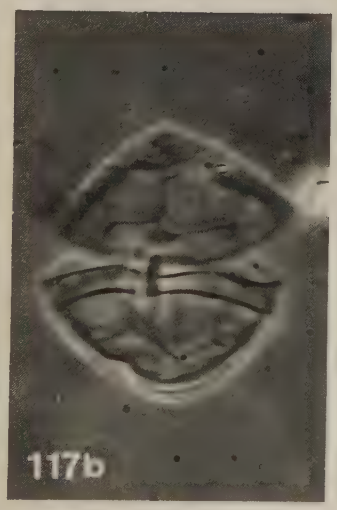
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PLATE XXXIV

PLATE XXXV

Figure 119. *Peridinium venustum.* Non-photosynthetic. a) Live. Ventral view. Similar to *P. oblongum*, ortho, quadra. Cingulum descending, 1X. Antapical horns divergent. 123 μ long. b) Preserved. Phase contrast. Ventral view. Four sided 1st apical evident. Theca reticulate with scattered pores. Anterior sulcal plate invades epitheca. Cingulum lists ribbed. 76μ wide.

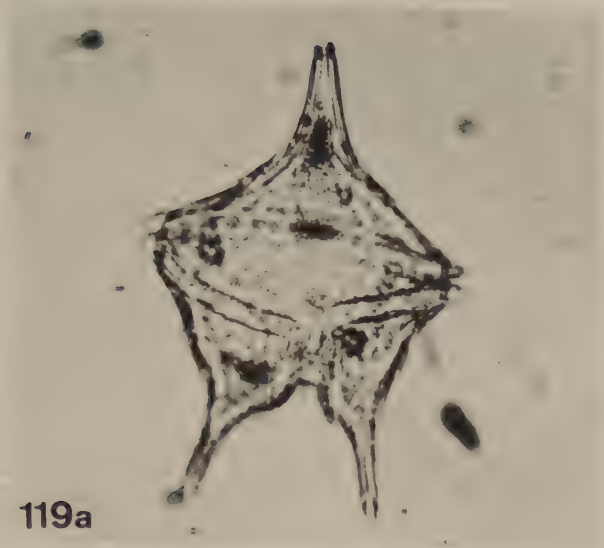
Figure 120. *Phalacroma apicatum.* Live. Lateral view. Similar to *P. argus,* but curvature of cingulum and epitheca differ. 100 μ long.

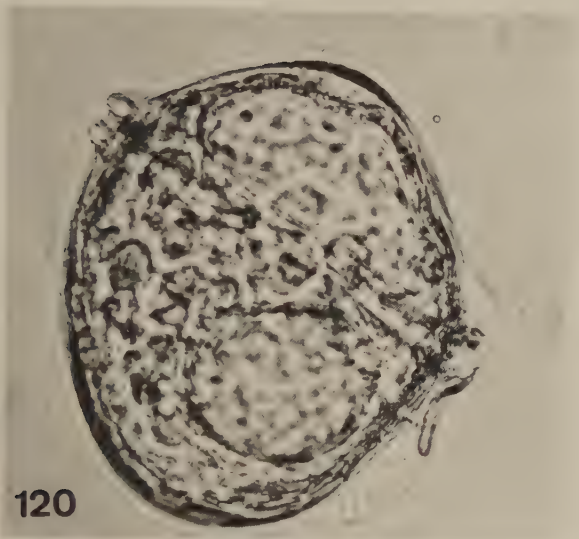
Figure 121. *Phalacroma argus.* Live. Lateral view. Epitheca about 1/3rd body length, cingular lists directed outwardly. Cingulum in lateral view, "dipped".

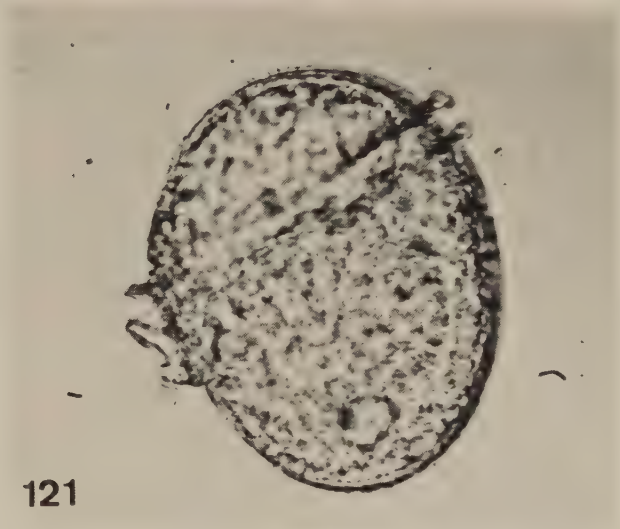
Figure 122. *Phalacroma cuneus.* Live. Lateral view. Epitheca above cingulum, deeper than hypotheca, both rounded. Cell cup-shaped, sulcal lists short. 112 μ deep.

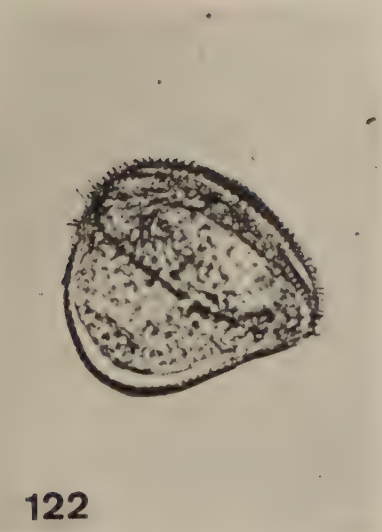
Figure 123. *Phalacroma rapa.* Live. Lateral view. Epitheca visible above cingulum. Body posteriorly lobed dorsally. Cell compressed, theca reticulate. Long posterior support rib (R_3). 88 μ long.

Figure 124. *Phalacroma rotundum.* Disassociated. Photosynthetic. Lateral view. One half only, note height of epitheca and outward direction of cingular lists. The term "interlocking sutural mesh" could be applied to the gear-like fission suture. Approximately 40 μ long.









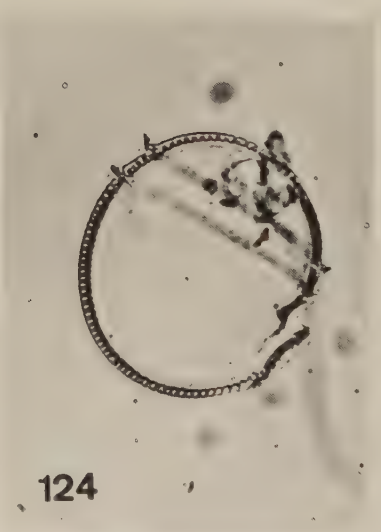


PLATE XXXV

PLATE XXXVI

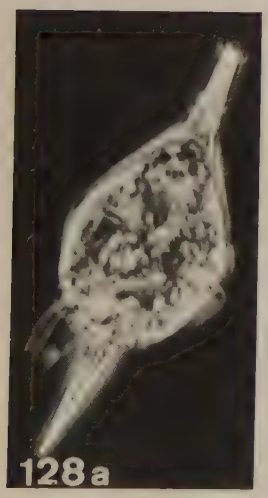
Figure 125. *Podolampas bipes.* Live. Non-photosynthetic. Phase contrast. Ventral view. Cingular area not composed of plates. Pear-shaped cell with apical horn and winged antapical spines. 56 μ wide.

Figure 126. *Podolampas reticulata.* Non-photosynthetic. a) Live. Ventral view. Similar to the species but with broader and reticulated posterior fins. 81 μ wide. b) Disassociated. Note point of separation, this area referred to as cingular area with precingulars above, postcingulars below, analogous to cingulum of other armored forms.

Figure 127. *Podolampas elegans.* Live. Non-photosynthetic. Ventral view. Delicate pear-shaped cell with two winged antapical spines. 53 μ long.

Figure 128. *Podolampas palmipes.* Non-photosynthetic. Phase contrast. a) Crushed. Lateral view. Pear-shaped cell with apical horn and solid antapical spines of unequal length. b) Live. Dividing cell illustrating oblique longitudinal division.

Figure 129. *Podolampas spinifer.* Live. Non-photosynthetic. Phase contrast. Semi-lateral view. Thecal plates difficult to discern, flagellum beats freely around breadth of cell. Apical horn with prominent spine. 132 μ long.



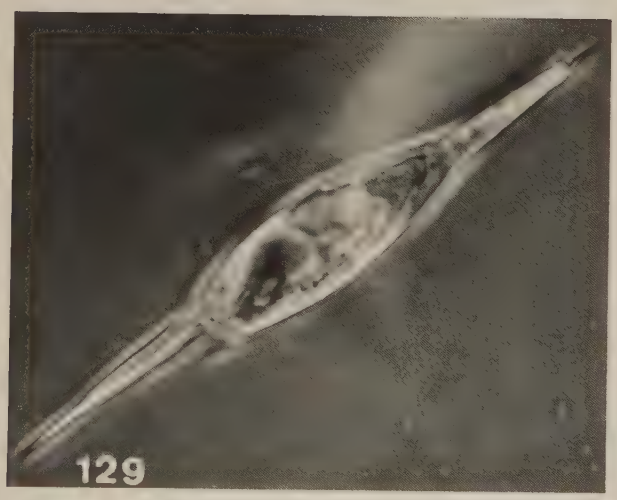


PLATE XXXVI

PLATE XXXVII

Figure 130. *Polykrikos hartmannii.* Live. Photosynthetic. Aberrant cluster of cells after division in culture. Densely pigmented, displaced cingulum, indented epicone. This species can grow as a single zooid whereby the epicone is conical rather than compressed and there are two nuclei. 105 μ long (cluster).

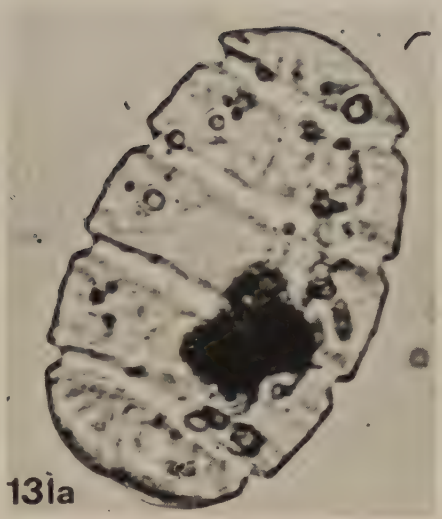
Figure 131. *Polykrikos schwartzii.* Live. Non-photosynthetic. a) Typical morphology of pseudocolonial arrangement, 4 zooids slightly rounded out. b) Specimen with 8 zooids, 4 nuclei, 2 flagella per zooid. Hypocone not ridged, but cingulum displaced, nematocysts present. Note phagocytized *Peridinium* in vacuole. 76 μ wide.

Figure 132. *Pronoctiluca acuta.* Live. Non-photosynthetic. Phase contrast. a and b) Characterized by apical flexible tentacle. Small, difficult to detect, when immobile could be mistaken for a small *Prorocentrum.* Cingulum premedian. Body-10 μ wide.

Figure 133. *Prorocentrum compressum.* Live. Photosynthetic. Phase contrast. Compressed, one valve with 2 short anterior processes. Valves thick and poroid, occasionally appeared aereolate. 37 μ long.

Figure 134. *Prorocentrum gracile.* Photosynthetic. a) Preserved. Note narrow lanceolate body and prominent tooth, cells occasionally with serrated periphery. b) Same specimen. Orientation with fission suture forward. Tooth with hyaline fringe. At times this protrusion could be mistaken for the spade-like tooth of *P. hentschelii.* c) Disassociated. Phase contrast. Both left and right valves showing trichocyst pores. 51 μ long.

130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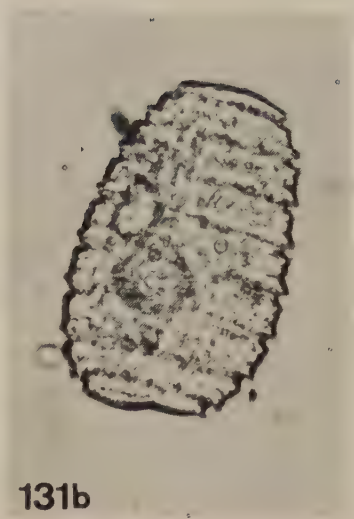
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PLATE XXXVII

PLATE XXXVIII

Figure 135. *Prorocentrum maximum.* Live. Photosynthetic. Characterized by elongate body, anterior tooth, anterior hump and diagonally arranged pores located posteriorly.

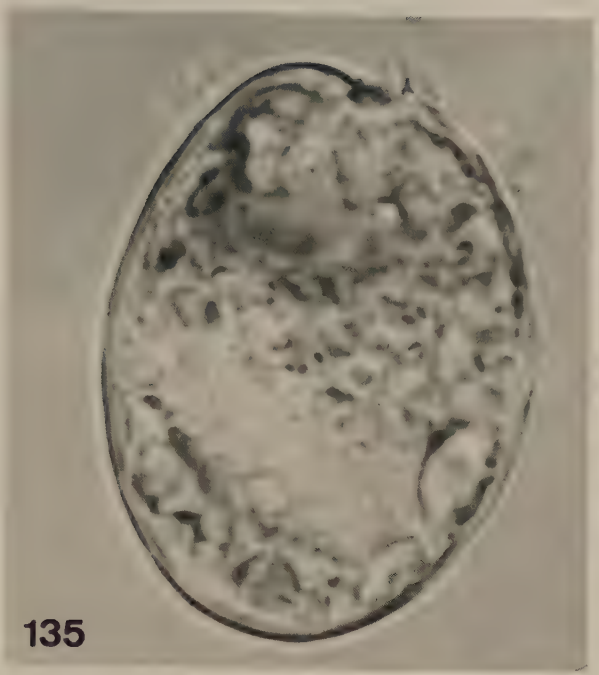
Figure 136. *Prorocentrum micans.* Photosynthetic. a) Preserved. Anterior tooth prominent, valves somewhat heart-shaped and poroid. 22 μ wide. b) Disassociated. Cytoplasm encysted and expelled, valves more typical of *P. micans* but less characteristic of our dominant form.

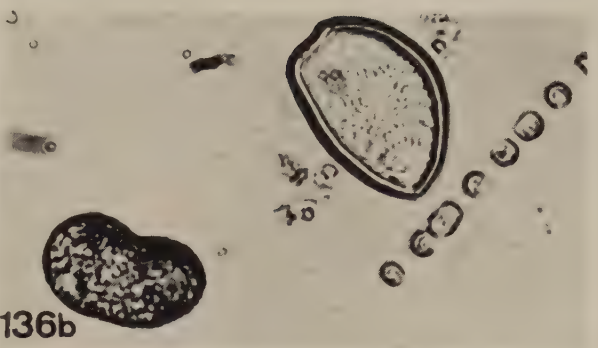
Figure 137. *Prorocentrum pyriforme.* Disassociated. Photosynthetic. Phase contrast. Very hyaline valves with few marginal poroids. 27 μ long.

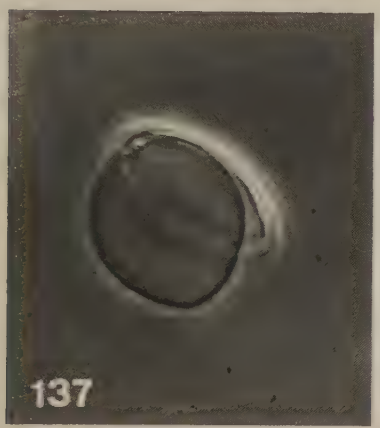
Figure 138. *Prorocentrum rostratum.* Disassociated. Photosynthetic. Elongate body with tapered antapex and rostrum-like apical process. 53 μ long.

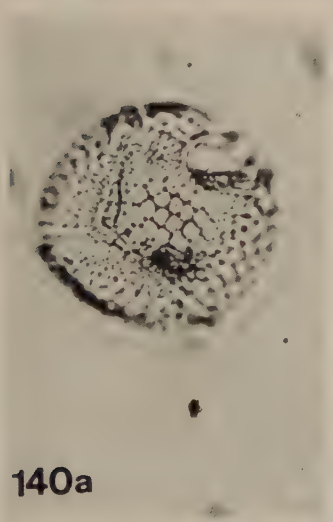
Figure 139. *Prorocentrum* sp. Crushed. Surface lightly reticulate. Apical processes tubular. 39 μ long.

Figure 140. *Protoceratium reticulatum.* Disassociated. Photosynthetic. a) Antapical view. Note extension of sulcal area on hypotheca, large antapical plates and postcingulars. b) Apical view. Pore platelet evident, apical plates and precingulars below. 35 μ wide. c)Phase contrast. Plates spearated, theca highly reticulated.









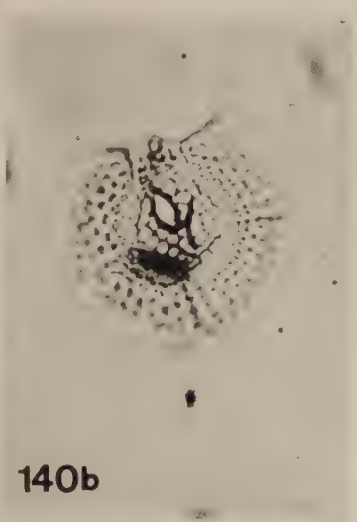


PLATE XXXVIII

PLATE XXXIX

Figure 141. *Ptychodiscus noctiluca.* Live. Photosynthetic? Specimen recently rounded out, with thick pellicle or theca. Apical area with keel. 53 μ wide.

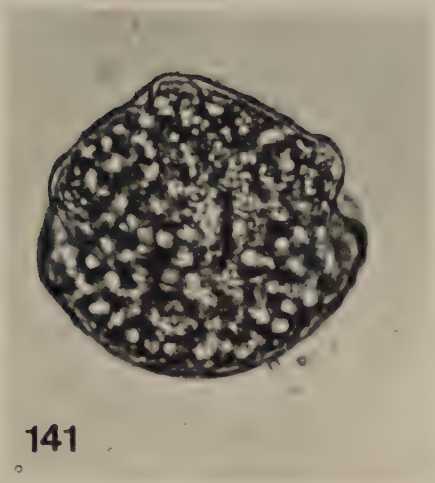
Figure 142. *Pyrocystis fusiformis.* Live. Photosynthetic. Pellicle wrinkled due to surface tension pulling cell to periphery of droplet. Cell typically fusiform. 204 μ wide.

Figure 143. *Pyrocystis pseudonctiluca.* Live. Photosynthctic. Encysting cell (?), note radiating protoplasm with centrally concentrated mass. Diameter – 286 μ.

Figure 144. *Pyrocystis pseudonoctiluca* f. *biconica.* Live. Photosynthetic. Cell not typical, lost characteristic biconical shape after several days maintenance in natural seawater.

Figure 145. *Pyrodinium bahamense.* Live. Photosynthetic. Shows extensive wing complexes characteristic of species. Similar to *Gonyaulax.* 62 μ wide.

Figure 146. *Pyrophacus horologium.* Photosynthetic. a) Live. Encysted cell, cyst expanded, separating epitheca from hypotheca. Cyst– 34 μ long. b) Disassociated. Phase contrast. Hypothecal view, 9 ''', O*a* and 4'''',



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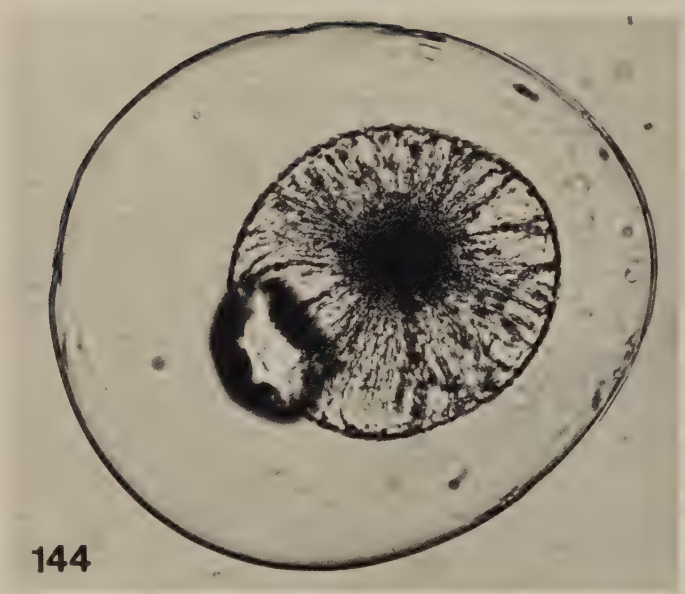

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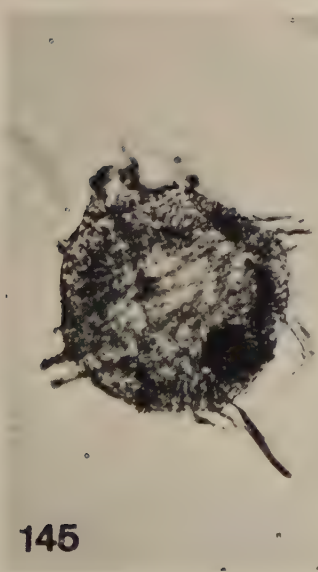

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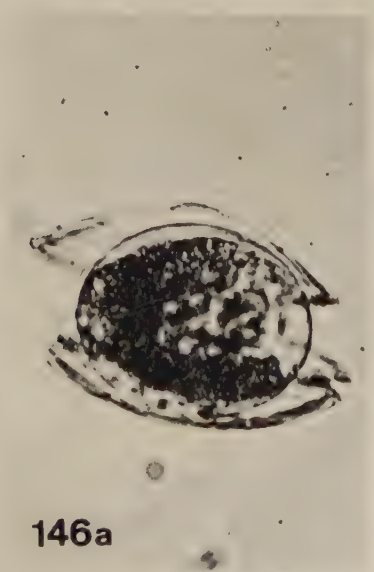
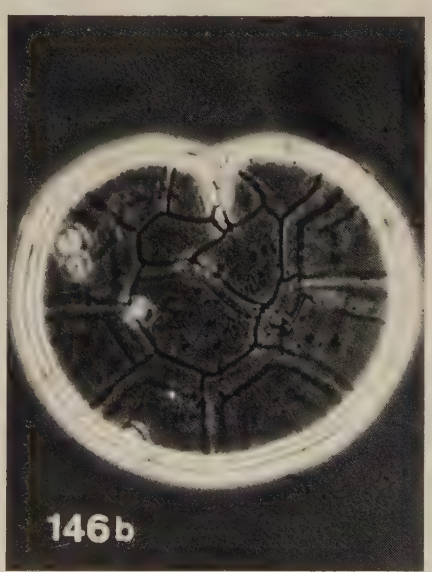


146a



146b

PLATE XXXIX

PLATE XL

Figure 147. *Pyrophacus horologium* var. *steinii.* Live. Photosynthetic. Phase contrast. Protoplasm encysted, theca exuviated. Plate formula: 7', O*a*, 12", 12(?)c, 12‴, O*p* and 6⁗. Hypotheca – 96 μ wide.

Figure 148. *Pyrophacus horologium* form B_1. Disassociated. Photosynthetic. Phase contrast. Hypotheca with plate formula: 14", 2*p* and 8⁗. 123 μ wide.

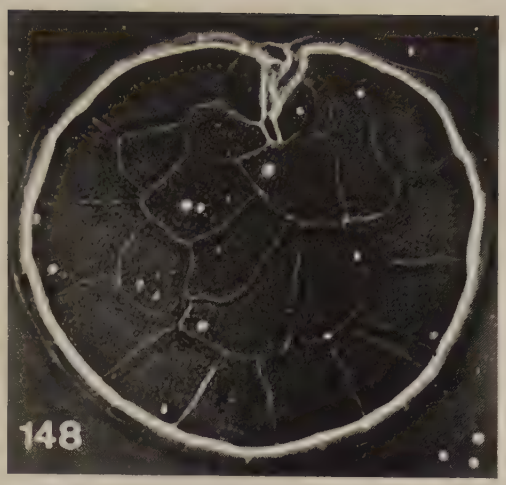
Figure 149. *Torodinium robustum.* Live. Photosynthetic. Small species, less pigmented (yellow-green) than *T. teredo* (brown). Epicone occupies most of body. Cingulum located posteriorly with sulcus extending almost to the apex. Approximately 20 μ long.

Figure 150. *Torodinium teredo.* Live Photosynthetic. Longtitudinal view showing excessive epicone and the location of cingulum. Approximately 72 μ long.

Figure 151. *Warnowia* A. Live. Non-photosynthetic. a) Cingulum descending with more than one revolution. Ocellus (lens and melanosome) located anteriorly. Possible trichocysts lining periphery. 140 μ long. b) Same specimen.

Figure 152. Unidentified cyst. Live. Photosynthetic. Four daughter products each with dinophycean nucleus. Resembles a *Pyrophacus* cyst. Cysts in the plankton are often impossible to identify without prior knowledge of species.

147


148

149

150

151a

151b

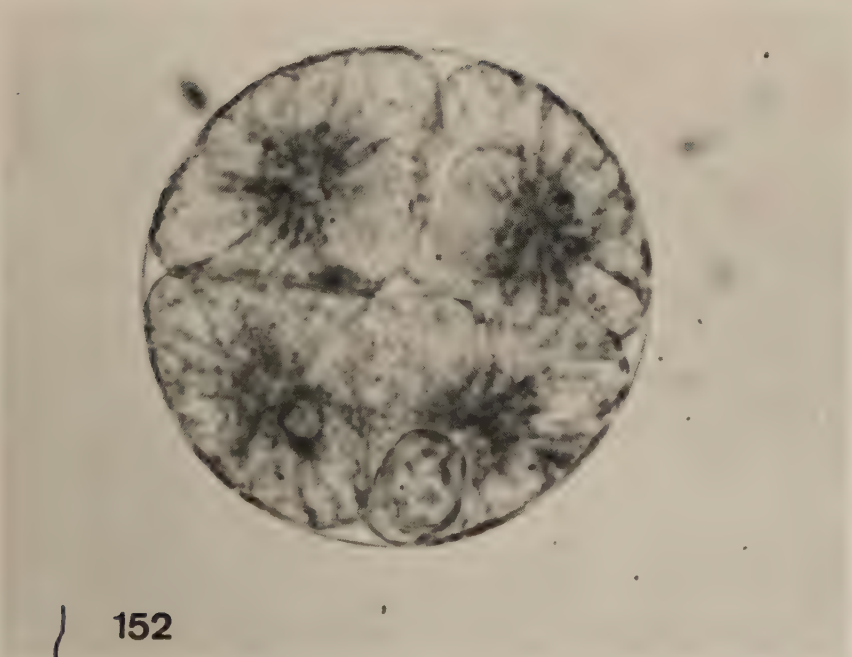

152

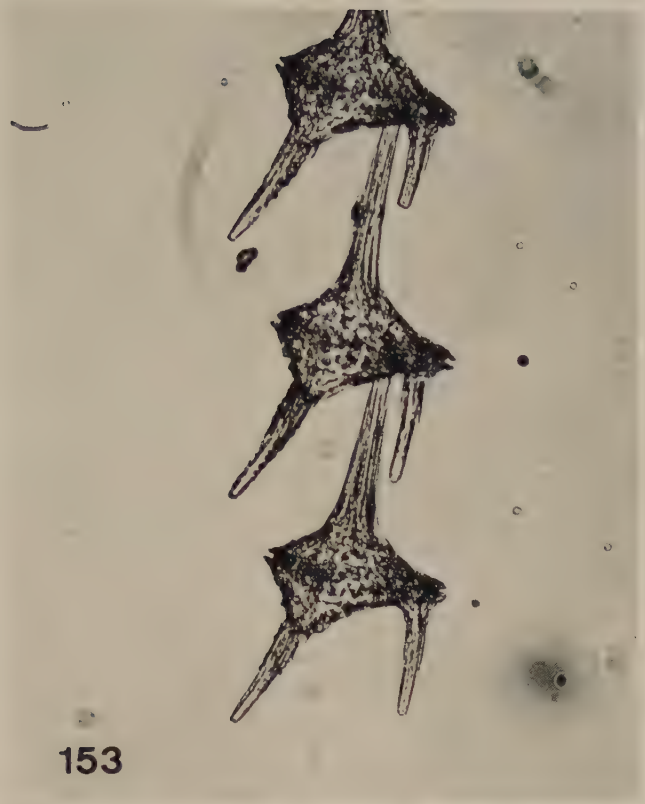
PLATE XL

PLATE XLI

Figure 153. *Ceratium candelabrum* var. *depressum.* Live. Photosynthetic. Catenate species. Note direction of antapical horns and angularity of body. Epitheca – 91 μ wide.

Figure 154. *Ceratium schroteri.* Preserved. Photosynthetic. Dorsal view. Boot-shaped cell, epitheca slightly swollen, tapered distally. Antapicals unequal, left gently curved. 224 μ long.

Figure 155. *Ceratium vultur.* Preserved. Photosynthetic. Species with thickened epitheca, apical horn and antapical horns. Compare to the variety *sumatranum* for the curvature and direction of antapicals. Note the difference among daughter cells in antapical horn development.


153

154

155

PLATE XLI

NON-HOURGLASS SPECIES
FROM GULF OF MEXICO AND CONTIGUOUS WATERS

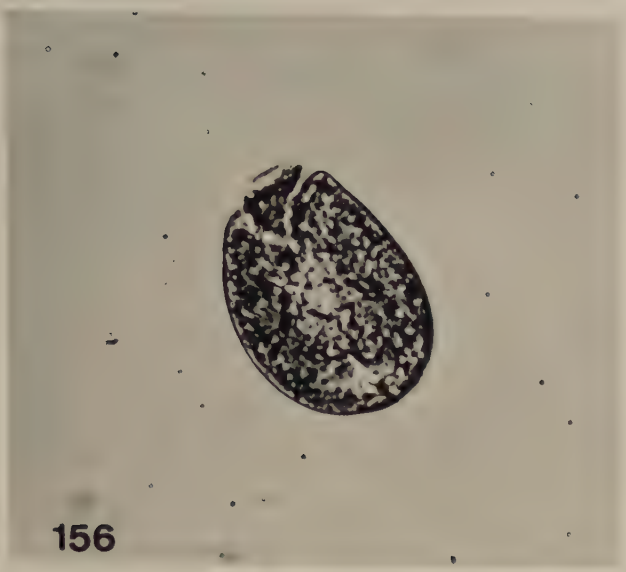
PLATE XLII

Figure 156. *Amphidinium klebsii.* Live. Photosynthetic. Ventral view. Anvil-like epicone, reduced and directed laterally. 39 μ long.

Figure 157. *Ceratium gravidum.* Preserved. Photosynthetic. Ventral view of epitheca. Most *Ceratium* are characterized by an apical horn, this species and several related forms are exceptions with a rounded spatula-like epitheca. Epitheca with large pore.

Figure 158. *Ceratium limulus.* Preserved. Photosynthetic. Short compressed species. Characteristically humped at base of apical horn. Antapex rounded. Theca rugose. 110 μ long.

Figure 159. *Ceratium praelongum.* Live. Photosynthetic. Ventral view. Of the same type as *C. gravidum*, with expanded epitheca, unequal antapical horns directed posteriorly. Epitheca – 81 μ wide.



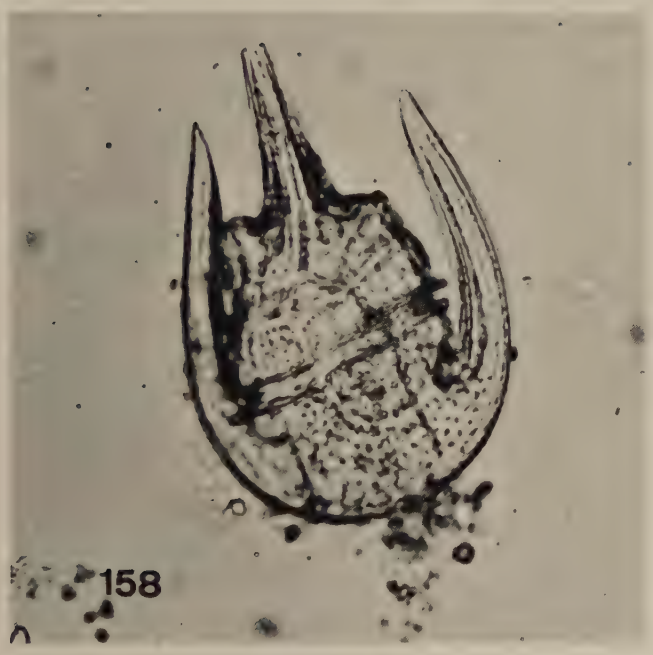


PLATE XLII

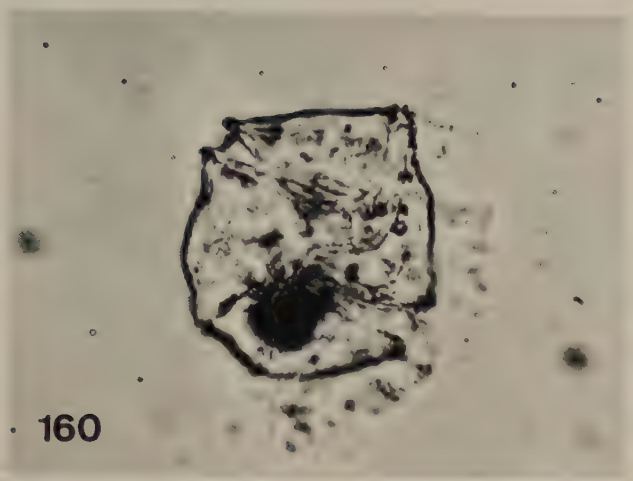
PLATE XLIII

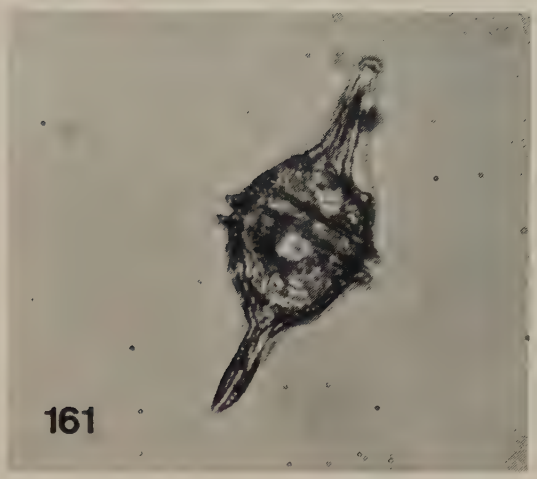
Figure 160. *Gonyaulax alaskensis.* Crushed. Photosynthetic. Ventral surface focused through dorsal side, thus reversing characters. Cingulum actually descending, greater than 3X, about 4.5μ wide. Species broad and deep with modified apical process.

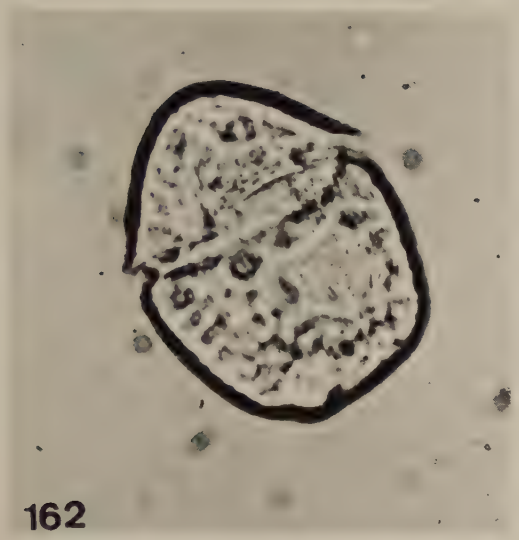
Figure 161. *Gonyaulax birostris.* Live. Photosynthetic. Lateral view. Note characteristic apical and antapical processes. Cingulum displaced about 1.5X. 133 μ long.

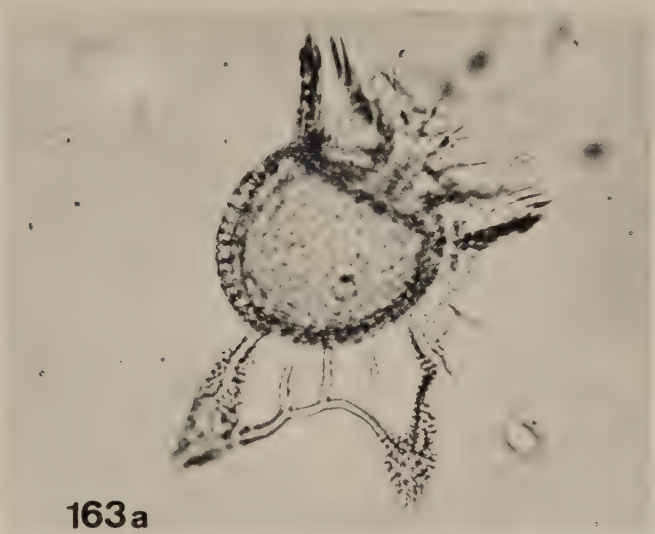
Figure 162. *Gymnodinium multistriatum.* Live. Cell rounding out, 4-5X as many striations on hypocone as epicone. Cingulum premedian, displaced. 82 μ long.

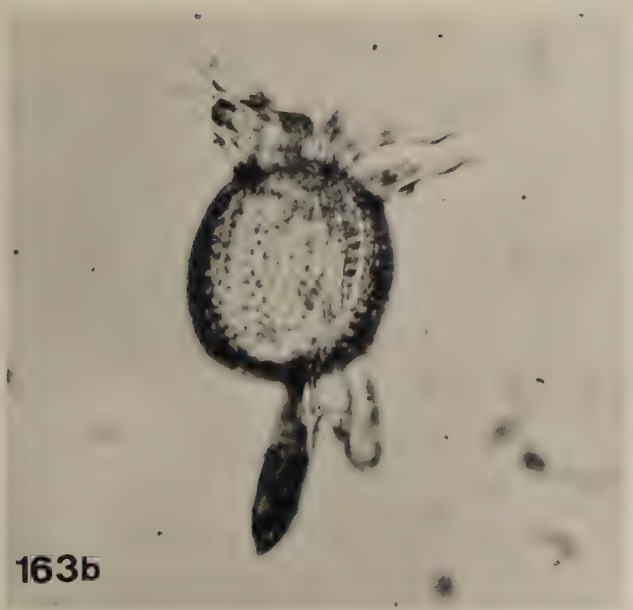
Figure 163. *Ornithocercus heteroporus.* Live. Non-photosynthetic. Body dorso-ventrally oblique, sulcal list not extending dorsally, list reticulated with support ribs. Theca heavily sculptured. Body – 34 μ deep. a) Lateral view. b) Ventral view. c) Dorsal view.


160


161


162


163a


163b

163c

PLATE XLIII

PLATE XLIV

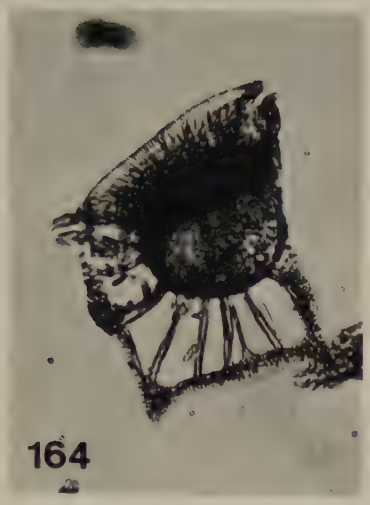
Figure 164. *Ornithocercus quadratus.* Live. Non-photosynthetic. Lateral view. Left sulcal list extends up dorsal side, quadrate. 144 μ long.

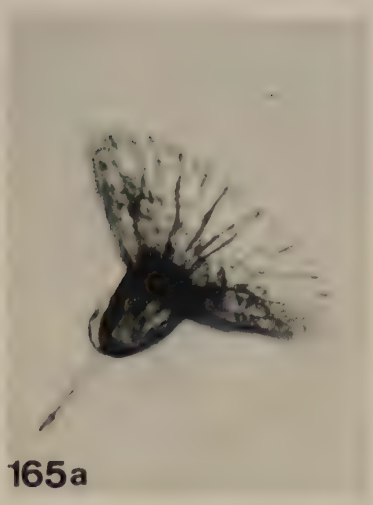
Figure 165. *Ornithocercus splendidus.* Live. Non-photosynthetic. a) Dorsal view. Very wide cingular lists, extension of left sulcal list outstanding. Body – 30 μ wide. b) Same specimen, apical view. Note dendrite anterior cingular list. Globular bodies are probably associated zooxanthellae.

Figure 166. *Parahistioneis* sp. Crushed. Theca aerolate, sulcal list extending posteriorly, singly lobed with support spine. Body – 43 μ wide.

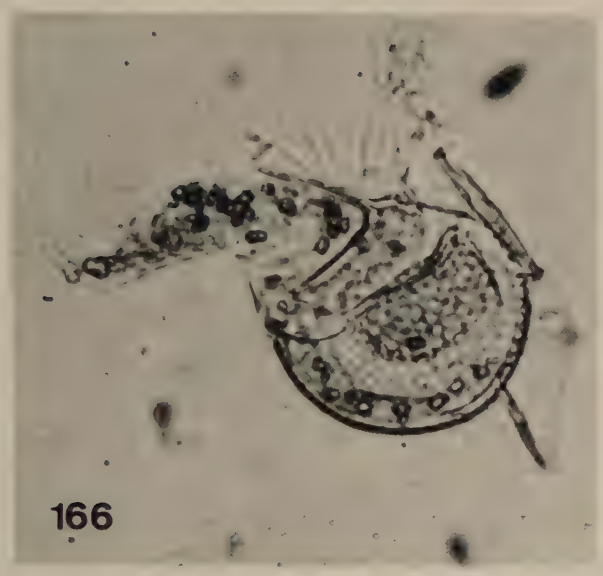
Figure 167. *Peridinium subsalsum.* This species should probably be transferred to *Scrippsiella.* Live. Photosynthetic. a) Ventral view. Cingulum displaced, greater than 1X. Note postcingular plate extensions appearing as wings. b) Slightly rounded out, projection represents left sulcal list. c) Lateral view. Note oblique axis and cingulum displacement which is not typical for *P. subsalsum.* 49 μ deep.

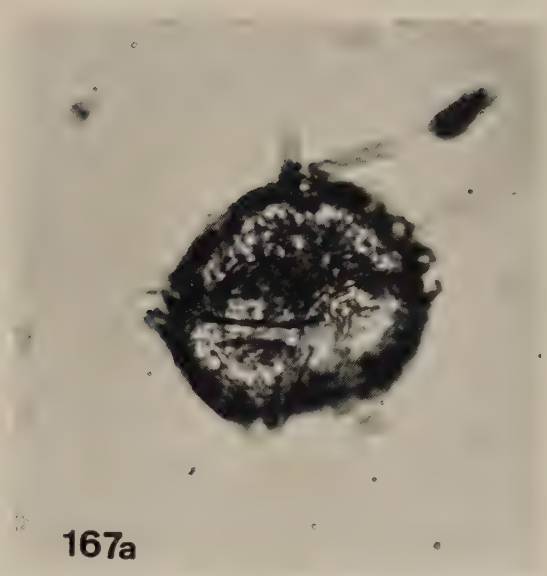
Figure 168. *Phalacroma doryphorum.* Live. Non-photosynthetic. Phase contrast. Lateral view. Body ovoid, epitheca conical. Left sulcal list broadly bidentate including posterior sail with support rib, not extending dorsally.


164

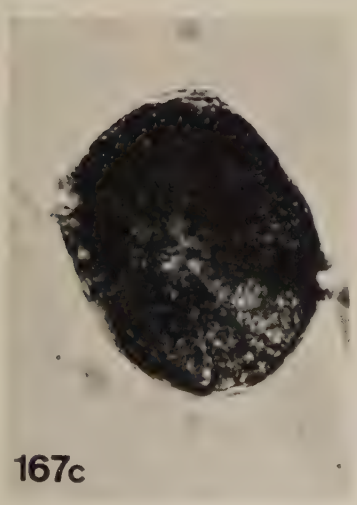

165a

165b


166


167a

167b


167c

168

PLATE XLIV

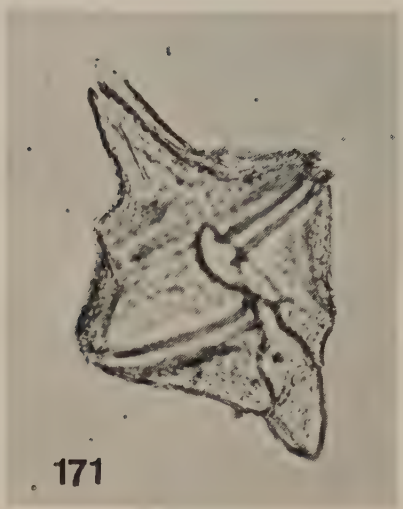
PLATE XLV

Figure 169. *Phalacroma hindmarchii.* Live. Non-photosynthetic. Phase contrast. Lateral view. Hypotheca with broad protuberance. Left sulcal list ventral not extending to antapex.

Figure 170. *Prorocentrum triestinum.* Live. Photosynthetic. Similar to *P. micans* in almost all characters except size. Antapex broader than *P. micans.* 18 μ long.

Figure 171. *Spiraulax jollifei.* Preserved. Ventral view. Cingulum displacement greater than 3X, apices pointed, attenuated epitheca and hypotheca. 1st apical plate not in contact with anterior sulcal plate. 110 μ long.

Figure 172. Unidentified thecate #2. Photosynthetic. a) Live. Lateral view. Resembles *Phalacroma* but with weak theca and short sulcal lists. Lobed antapex. Body – 48 μ long. b) Disassociated. Phase contrast. Theca poroid, large hypothecal plates.



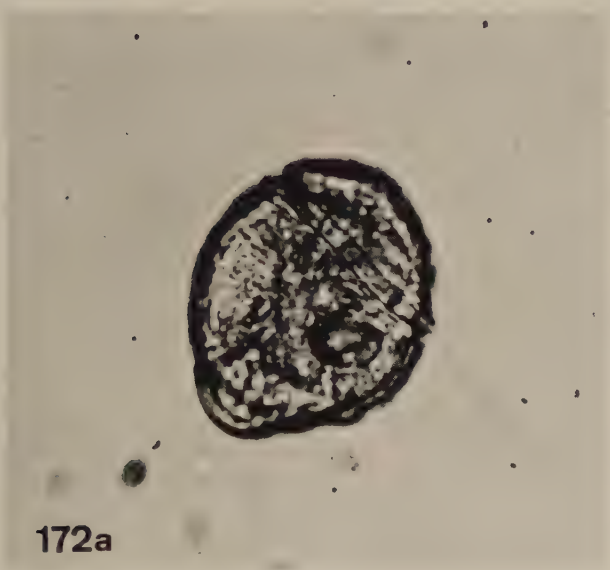


PLATE XLV

APPENDIX 1: OTHER DINOFLAGELLATES RECORDED FROM THE GULF OF MEXICO*

Acanthogonyaulax
- *A. spinifera*

Amphidinium
- *A. fusiformis*
- *A. herdmanii*
- *A. kesslitzii*
- *A. operculatum*

Amphidoma
- *A. acuminata*

Amphisolenia
- *A. globifera*
- *A. lemmermannii*
- *A. palaeotheroides*
- *A. schauinsland*
- *A. schroderi*
- *A. thrinax*

Centrodinium

Ceratium
- *C. arietinum*
- *C. azoricum*
- *C. brachyceros*
- *C. breve*

C. candelabrum
- *C. carolinianum*
- *C. deflexum*
- *C. digitatum*
- *C. euarcuatum*
- *C. falcatiforme*
- *C. fusus* f. *seta*
- *C. hirundinella*
- *C. horridum*
- *C. incisum*
- *C. lanceolatum*
- *C. longipes*
- *C. longissimum*
- *C. macroceros*
- *C. paradoxides*
- *C. pavillardii*
- *C. pentagonum*
- *C. pentagonum* var. *subrobustum*
- *C. platycorne*
- *C. recurvum*
- *C. reflexum*
- *C. tenue*
- *C. tripos*
- *C. vultur* f. *japonicum*

Ceratocorys
- *C. bipes*
- *C. reticulata*

Citharistes
- *C. apsteinii*

Cladopysis
- *C. brachiolata*
- *C. hemibrachiata*

Cochlodinium
- *C. achromaticum*
- *C. archimedes*

Dinophysis
- *D. brevisulcus*

D. exigua
- *D. expulsa*
- *D. micropterygia*
- *D. monacantha*
- *D. odiosa*
- *D. pusilla*
- *D. recurva*
- *D. rotunda*
- *D. schroederi*
- *D. schuettii*
- *D. similis*
- *D. simplex*
- *D. sphaerica*
- *D. swezyii*
- *D. tripos*
- *D. uracantha*

Diplopsalis
- *D. lebourae*
- *D. ovatum*
- *D. sphaerica*

Dolichodinium
- *D. lineatum*

Ensiculifera
- *E. mexicana*

Glenodinium
- *G. danicum*
- *G. oculatum*

Gleodinium

Gonyaulax
- *G. apiculata*
- *G. buxus*
- *G. cohorticula*
- *G. concava*
- *G. fusiformis*
- *G. kofoidii*
- *G. milneri*
- *G. monacantha*
- *G. pacifica*
- *G. polygonatum*
- *G. sphaeroidea*
- *G. tamerensis (?)*
- *G. tamarensis* var. *excavata*
- *G. tricantha*

Gymnodinium
- *G. aeruginosum*
- *G. alba*
- *G. albulum*
- *G. biconicum*
- *G. fuscum*
- *G. hyalinum*
- *G. minor*
- *G. minutum*
- *G. pellucidum*
- *G. simplex*
- *G. variabile*
- *G. translucens*

Gyrodinium
- *G. lachryma*
- *G. pingue*

Hemidinium
- *H. naustum*

Heterodinium
- *H. agassizi*
- *H. globosum*
- *H. hindmarchii*
- *H. inequale*
- *H. leiorhynchum*
- *H. mediocre*
- *H. mediterraneum*
- *H. milneri*
- *H. murrayii*
- *H. pavillardii*
- *H. ridgenae*
- *H. scrippsii*
- *H. whittingae*

Heteroschisma
- *H. inaequale*
- *H. longialata*
- *H. pirum*

Histioneis
- *H. biremis*
- *H. cymbalaria*
- *H. dolon*
- *H. helenae*
- *H. hippoperiodes*
- *H. jorgensenii*
- *H. milneri*
- *H. panda*

Hypodium
- *H. sphericum*

Katodinium
- *K. glandula*

Mataphalacroma
- *M. skogsbergii*

Murrayella
- *M. mimetica*
- *M. splendida*

Nematodinium

Noctiluca
- *N. miliaris*

Ornithocercus
- *O. carolinae*
- *O. cristatus*
- *O. francescae*
- *O. orbiculatus*

Oxytoxum
- *O. carinatum*
- *O. constrictum*
- *O. cristatum*
- *O. gladiolus*
- *O. latum*
- *O. parvum*
- *O. turbo*

Parahisitoneis
- *P. paraformis*

Peridinium
- *P. anguipes*
- *P. brintoni*
- *P. digatale*
- *P. garderae*
- *P. granii* f. *mite*
- *P. gymnodinium*

P. inclinatum
P. incinspicum
P. latidorsale
P. latispinum
P. latum
P. mediterraneum
P. minuscula
P. monospinosum
P. nux
P. obtusum
P. oceanicum
P. patens
P. pedunculatum
P. pulvisculus
P. quadridens
P. roseum
P. simulum
P. sphaeroides
P. subsphaericum
P. tabulatum
P. tenuissimum
P. triquetrum
P. tristylum
P. umbonatum
P. willneri
P. wisconiensis

Phalacroma
P. acutum
P. circumsutum
P. elongatum
P. limbatum
P. mucronatum
P. operculoides
P. parvulum
P. paulsenii

Polykrikos
P. lebourae

Prorocentrum
P. minimum
P. obtudidens
P. scutellum
P. spiniulisum
P. tringulatum

Protoceratium
P. spinulosum

Protodinium
P. balticum

Pseudophalacroma
P. nasutum

Pyrocystis
P. hamulus
P. noctiluca
P. robusta

Scrippsiella
S. sweeneyae

Spirodinium

Thecadinium
T. kofoidii

Triposolenia
T. bicornis
T. truncata

Warnowia
W. polyphemus

* This list includes those dinoflagellate species listed by other workers that are not mentioned in this Memoir. It was compiled from the following references: Balech, 1967; Curl, 1959; Davis, 1950; Dragovich, 1961; Dragovich and Kelly, 1964; Florida State University, 1958; Graham, 1954; King, 1950; Lackey, 1967; Lackey and Hynes, 1955; Simmons and Thomas, 1962; Steidinger, Davis and Williams, 1966, 1967a, 1967b; Wood, 1968. In Wood (1968) only those species that were found in Gulf of Mexico waters or associated estuarine waters are incorporated.

APPENDIX II: SEASONALITY

Those that were not recorded yearly but showed some seasonal pattern may only represent minimum seasonality. Tow sample data often expanded the seasonal picture, but not all tow material was analyzed. Had this been accomplished, more species may have shown wider seasonal occurrences. An asterisk indicates tow material only.

ALL SEASONS

Amphidinium crassum
Blepharocysta paulensi ?
Blepharocysta splendor-maris
Ceratium carriense
Ceratium carriense var. *volans*
Ceratium contortum var. *contortum*
Ceratium contortum var. *karstenii*
Ceratium declinatum f. *normale*
Ceratium extensum
Ceratium furca
Ceratium fusus
Ceratium hexacanthum
Ceratium hircus
Ceratium inflatum
Ceratium lineatum
Ceratium longirostrum
Ceratium lunula
Ceratium macroceros var. *gallicum*
Ceratium massiliense
Ceratium minutum
Ceratium pentagonum var. *tenerum*
Ceratium trichoceros
Ceratium tripos var. *atlanticum*
Ceratium tripos var. *ponticum*
Ceratocorys armata
Ceratocorys horrida
Cochlodinium citron ?
Cochlodinium A
Dinophysis caudata var. *pedunculata*
Dinophysis caudata var. B
Diplopsalis lenticula
Diplopsalis lenticula f. *asymmetrica*
Diplopsalis rotundata
Fragilidium sp.
Gonyaulax diacantha
Gonyaulax diegensis
Gonyaulax digitalis
Gonyaulax fragilis
Gonyaulax monilata
Gonyaulax polyedra
Gonyaulax polygramma
Gonyaulax spinifera
Gonyaulax turbynei
Gymnodinium breve
Gymnodinium coeruleum
Gymnodinium splendens
Gymnodinium E
Gyrodinium falcatum
Gyrodinium fissum
Gyrodinium spirale
Gyrodinium F
Heteraulacus acuminatus
Katodinium glaucum
Oxyhrris marina
Oxytoxum gigas
Peridinium breve
Peridinium brochii
Peridinium claudicans
Peridinium conicum
Peridinium crassipes
Phalacroma argus
Peridinium depressum
Peridinium divergens
Peridinium globulus
Peridinium globulus var. *quarnerense*
Peridinium granii?
Peridinium nipponicum
Peridinium oblongum
Peridinium pellucidum
Peridinium subinerme
Peridinium subinerme var. *punctulatum*
Peridinium trochoideum (=Scrippsiella?)
Peridinium venustum
Peridinium D
Podolampas palmipes
Pronoctiluca acuta
Prorocentrum aporum
Prorocentrum compressum
Prorocentrum gracile
Prorocentrum micans
Prorocentrum C
Protoceratium reticulatum
Pyrocystis fusiformis
Pyrocystis pseudonoctiluca
Pyrophacus horologium
Pyrophacus horologium var. *steinii*
Torodinium robustrum
Torodinium toredo
*Unidentified thecate

FALL

* *Amphisolenia* B
* *Amphisolenia* C
Ceratium semipulchellum
Cochlodinium B
Coolia monotis
Dinophysis caudata var. *abbreviata*
Dinophysis fortii
Gymnodinium G
Gyrodinium caudatum
Katodinium roundata
Oxytoxum sp. *(curvicaudatum?)*
Peridinium curvipes?
Peridinium leonis f. *matzenaueri*
Peridinium spiniferum
Peridinium O
Peridinium P
Peridinium U
Phalacroma apicatum
Phalacroma C
Podolampas elegans
Ptychodiscus noctiluca
Warnowia A

WINTER

Amphidinium scissum
* *Amphisolenia rectangulata*
Ceratium contortum var. *subcontortum*
* *Ceratium schroteri*
Peridinium pallidum var. *schilleri?*
* *Peridinium quinquecorne*
Peridinium N
Phalacroma A
Phalacroma B
Prorocentrum rostratum

SPRING

Amphidinium pelagicum
Ceratium concilians
* *Ceratium ranipes*
Gonyaulax hyaline
Gymnodinium incisum
Gymnodinium K
Peridinium novascotiense?
Peridinium pyriforme?
Peridinium tuba?
Peridinium wiesneri?
Prorocentrum arcuatum
Prorocentrum perforatum

SUMMER

Blepharocysta A
* *Ceratium bigelowii*
* *Ceratium bucephalum*
Ceratium pulchellum
Dinophysis caudata var. *diegensis*
Dinphysis hastata
Diplopsalis orbicularis
Dissodinium lunula (V)
* *Gonyaulax acatenella*
* *Gonyaulax* sp. (catenate)
Gymnodinium F
Gymnodinium H
Gymnodinium J
Gyrodinium H
Oxytoxum milneri
Oxytoxum tesselatum
Oxytoxum A
Peridinium brochii var. *inflatum*
Peridinium claudicans/oblongum
* *Peridinium fatulipes*
* *Peridinium solidicorne?*
* *Peridinium steinii*
Peridinium L
* *Podolampas bipes*
* *Prorocentrum marinum* var. *lima*
Prorocentrum oblongum
Protoceratium areolatum
Pyrodinium schilleri

SUMMER, FALL

Amphisolenia bifurcata
Blepharocysta B
Dinophysis ovum
Dinophysis caudata var. A
Glenodinium B
Gonyaulax E
Gymnodinium I
Gyrodinium G
Peridinium abei
Peridinium excentricum
**Peridinium grande*
Podolampas reticulata

FALL, WINTER

Actiniscus pentasterias
Ceratium horridum?
**Ceratium vultur* var. *sumatranum*
Gymnodinium A
Peridinium pentagonum var. *latissimum*
Peridinium T
Pyrocystis fusiformis f. *biconica*

WINTER, SPRING

Ceratium kofoidii
Ceratium symmetricum var. *coarctatum*
Peridinium conicoides
Polykrokos kofoidii

SPRING, SUMMER

Ceratium candelabrum var. *depressum*
Ceratium gibberum var. *dispar*
Ceratium humile?
Ornithocercus steinii
Peridinium longipes
Peridinium ovum
Phalacroma mitra
Phalacroma rapa
Prorocentrum marie-lebourae

SUMMER FALL, WINTER

**Ceratium vultur*
Peridinium biconicum
Peridinium pentagonum
Podolampas spinifer
Prorocentrum maximum

FALL, WINTER, SPRING

**Ceratium belone*
Ceratium falcatum
Phalacroma rotundatum
Polykrikos schwartzii

WINTER, SPRING, SUMMER

Amphisolenia bidentata
Ceratium buceros f. *tenue*
Ceratium trichoceros var. *contrarium*
Dinophysis caudata
Dinophysis C
Diplopsalis lenticula f. *minor*
Dissodinium lunula (I)
Heteraulacus sphaericus
Ornithocercus magnificus
Peridinium globulus var. *ovatum*
Prorocentrum marinum
Pyrophacus horologium form B_1

SPRING, SUMMER, FALL

Ceratium teres
Dinophysis caudata var. *acuminiformis*
Glenodinium A
Gonyaulax scrippsae
Oxytoxum scolopax
Peridinium elegans
**Peridinium elegans* var. *granulata*
Peridinium leonis?
Peridinium minutum
Polykrikos hartmannii
Pyrodinium bahamense

SPRING, FALL

Amphidinium carteri
**Ornithocercus thumii*
Oxytoxum elegans
Peridinium pallidum
Prorocentrum pyriforme

APPENDIX III: SIGNIFICANT SPECIES AND BIOMASS VALUES IN μ^3

Amphisolenia bidentata
67,039 – 95,406

Blepharocysta splendor-maris

Ceratium carriense
637,219 – 1,115,367

C. carriense var. *volans*
622,206 – 1,196,643

C. contortum var. *karstenii*
943,121 – 1,655,573

C. extensum
189,709 – 323,546

C. furca
23,157 – 43,369

C. fusus
34,463 – 154,722

C. hexacanthum
687,593 – 1,384,016

Ceratium hircus(?)
211,709

C. inflatum
145,897 – 221,276

C. massiliense
543,762 – 1,002,222

C. trichoceros
104,110 – 357,437

C. tripos var. *atlanticum*
518,659 – 964,436

Dinophysis caudata var. *pedunculata.*
92,153 – 231,405

Diplopsalis lenticula f. *asymmetrica*

Gonyaulax polygramma

Gymnodinium breve

G. splendens
51,651

Heteraulacus acuminatus

Katodinium glaucum

P. depressum

P. crassipes
329,540

P. trochoideum (=Scrippsiella?)

Prorocentrum compressum

P. gracile
25,773

P. micans
65,412

Pyrophacus horologium

Torodinium robustum

T. teredo

APPENDIX IV: BLOOM SPECIES

If published and unpublished estuarine/neritic data obtained by this Laboratory is utilized, the following species might be termed "bloom" species. No specific concentration was chosen to delineate bloom conditions. "Bloom" in this paper implies a sudden increase in cell numbers over that which is normally encountered for that species. This usually represents concentrations of at least 50,000 to 100,000 cells/liter for the species listed below.

Amphidinium carteri
Ceratium fusus
C. hircus (?)
Coolia monotis
Gonyaulax diacantha
G. monilata
G. polygramma
Gymnodinium breve
Gymnodinium E
G. splendens
Gyrodinium fissum
Heteraulacus reticulatus(?)
Katodinium rotundatum
Oxyrrhis marina
Peridinium excentricum
Peridinium (=Scrippsiella) subsalsum
P. trochoideum (=Scrippsiella?)
P. quinquecorne
Polykrikos hartmannii
Prorocentrum gracile
P. mariae-lebourae
P. micans
Protoceratium reticulatum
Pyrodinium bahamense

APPENDIX V

Tables showing temperature, salinity, total number of unarmored species, total number of armored species, total number of genera, additional species found after filtration of sample, and total counts per sample for each Hourglass station: F and N (offshore stations), G and O (middle stations), and H and P (inshore stations).

STATION F

Cruise No.	Sample Depth	Salinity o/oo	Temp. °C	Un-armored	Armored	Total Genera	Filtered	Total Count
	Surface	28.76	29.0	2	0	2	0	2,166
18	Mid-depth	35.59	28.5	1	0	1	0	167
	Bottom	35.93	24.5	3	1	3	0	934
	Surface	35.44	28.4	3	2	3	2	1,983
19	Mid-depth	35.73	28.6	6	1	4	0	5,002.651
	Bottom	36.23	23.0	2	1	3	1	384
	Surface	35.93	27.5	5	3	6	2	10,917
20	Mid-depth	35.70	27.0	6	0	3	0	5,934
	Bottom	36.18	25.0	1	0	1	0	50
	Surface	35.84	24.5	4	3	5	3	1,484
21	Mid-depth	35.62	24.0	4	10	12	8	954
	Bottom	35.83	24.5	4	1	4	1	367
	Surface	35.87	22.0	4	9	7	10	1,717
22	Mid-depth	35.87	22.0	4	7	7	7	3,500
	Bottom	35.93	22.0	3	1	4	0	2,267
	Surface	36.14	21.0	6	15	13	13	6,634
23	Mid-depth	36.04	21.0	3	6	8	5	10,584
	Bottom	35.97	20.5	2	5	5	5	5,583
	Surface	36.06	17.5	4	11	8	10	53,384
24	Mid-depth	36.12	17.5	1	8	4	6	850
	Bottom	36.09	17.5	4	4	5	2	6,318
	Surface	36.02	19.0	7	13	11	5	12,485
25	Mid-depth	36.16	18.5	7	8	10	6	57,500
	Bottom	36.24	18.0	6	9	9	4	8,884
	Surface	35.54	19.0	9	9	10	3	14,735
26	Mid-depth	36.14	19.5	6	6	8	4	57,733
	Bottom	36.33	18.5	2	2	3	0	5,384
	Surface	36.33	23.5	4	12	7	7	6,267
27	Mid-depth	36.28	22.0	4	10	7	9	5,650
	Bottom	36.16	20.0	4	1	4	1	5,200
	Surface	35.74	26.5	6	12	10	5	7,650
28	Mid-depth	36.02	24.0	2	11	9	9	5,834
	Bottom	36.06	22.5	3	5	5	3	6,417
	Surface	36.06	27.0	2	3	5	2	650
29	Mid-depth	36.09	26.0	5	14	12	12	1,067
	Bottom	36.28	23.0	2	3	4	2	700
	Surface	36.18	28.5	3	11	7	6	6,050
30	Mid-depth	36.21	27.0	6	18	11	14	6,483
	Bottom	36.55	24.0	4	3	5	0	6,651
	Surface	36.00	29.5	4	1	4	0	250
31	Mid-depth	35.78	29.5	2	0	2	0	217
	Bottom	36.40	25.0	3	1	4	0	200
	Surface	35.61	28.0	2	1	3	1	6,050
32	Mid-depth	35.52	28.0	0	3	3	3	150
	Bottom	36.14	25.0	0	2	1	1	217

STATION F

Cruise No.	Sample Depth	Salinity o/oo	Temp. °C	Un-armored	Armored	Total Genera	Filtered	Total Count
	Surface	36.11	25.0	3	10	8	7	10,667
33	Mid-depth	36.07	25.0	3	3	6	3	5,533
	Bottom	36.14	25.0	2	5	6	5	584
	Surface	35.99	22.0	3	17	10	18	1,284
34	Mid-depth	35.92	22.0	2	12	8	12	934
	Bottom	35.88	22.0	4	5	6	0	1,201
	Surface	36.31	21.0	4	15	12	12	1,301
35	Mid-depth	36.31	21.0	7	12	12	11	1,184
	Bottom	36.26	20.5	4	8	6	7	717
	Surface	35.93	19.0	3	4	5	1	1,300
36	Mid-depth	36.14	19.0	7	13	11	12	8,633
	Bottom	36.16	19.0	2	6	5	5	5,633
	Surface	35.93	18.0	3	12	7	9	6,050
37	Mid-depth	36.02	18.0	6	1	4	1	6,385
	Bottom	36.04	17.5	3	2	4	1	5,817
	Surface	36.28	20.5	3	11	10	7	6,050
38	Mid-depth	36.33	20.5	2	9	7	9	6,333
	Bottom	36.19	19.5	2	0	2	0	5,050
	Surface	36.52	25.5	4	14	10	9	11,551
39	Mid-depth	36.55	24.5	4	8	10	5	1,333
	Bottom	36.30	22.0	5	4	4	2	801
	Surface	36.50	26.5	1	9	7	9	1,450
40	Mid-depth	36.19	22.5	5	11	9	12	5,700
	Bottom	36.21	22.5	4	3	5	3	867
	Surface	36.53	29.5	5	4	6	5	1,751
41	Mid-depth	36.23	25.5	4	7	9	6	5,567
	Bottom	36.19	20.5	3	2	4	2	5,267
	Surface	34.90	30.5	7	11	12	9	4,151
42	Mid-depth	36.23	24.5	9	6	9	6	1,267
	Bottom	36.28	20.5	5	5	6	4	1,350
	Surface	35.30	29.0	3	6	8	7	5,350
43	Mid-depth	35.31	29.0	3	9	9	9	5,500
	Bottom	36.31	21.0	3	1	4	2	5,100
	Surface	35.93	26.5	4	7	6	7	27,067
44	Mid-depth	35.90	26.5	4	7	7	5	27,134
	Bottom	36.45	23.0	3	6	6	6	5,350
	Surface	36.09	24.0	4	6	10	6	11,967
45	Mid-depth	36.09	24.0	2	3	5	3	10,150
	Bottom	36.42	22.5	2	1	3	0	10,167

STATION N

Cruise No.	Sample Depth	Salinity o/oo	Temp. °C	Un-armored	Armored	Total Genera	Filtered	Total Count
	Surface	36.07	29.2	3	2	4	0	2,317
18	Mid-depth	34.44	28.7	3	1	3	1	2,100
	Bottom	35.14	23.2	2	4	5	2	2,267
	Surface	31.42	28.9	7	2	6	2	21,417
19	Mid-depth	34.08	28.7	3	2	5	0	1,150
	Bottom	30.49	22.2	2	5	6	0	58,100
	Surface	35.75	26.5	4	4	5	2	400
20	Mid-depth	35.64	26.5	3	2	4	2	5,767
	Bottom	36.19	24.5	4	4	7	1	21,200
	Surface	35.81	23.5	5	2	6	3	10,367
21	Mid-depth	35.80	23.5	4	8	10	6	12,017
	Bottom	35.84	23.5	6	4	8	1	22,484
	Surface	36.04	21.5	2	14	8	7	9,217
22	Mid-depth	35.95	21.3	2	18	11	14	7,633
	Bottom	36.00	21.3	3	8	7	5	6,400
	Surface	35.92	19.5	6	7	10	7	7,667
23	Mid-depth	35.92	19.5	5	11	8	10	6,934
	Bottom	35.92	19.5	2	0	2	0	5,833
	Surface	36.33	20.0	6	12	11	9	2,101
24	Mid-depth	36.36	20.0	3	5	6	2	634
	Bottom	36.19	18.5	3	4	7	3	800
	Surface	35.85	20.5	6	23	13	6	15,184
25	Mid-depth	36.19	19.0	3	4	5	3	6,367
	Bottom	36.16	20.5	4	5	7	4	6,083
	Surface	35,70	20.0	9	13	13	5	8,551
26	Mid-depth	36.23	20.0	6	4	5	3	50,684
	Bottom	36.31	19.0	4	2	5	0	5,650
	Surface	36.00	24.5	6	13	9	10	8,700
27	Mid-depth	36.06	24.0	5	10	7	11	6,600
	Bottom	36.18	21.5	6	2	5	1	6,250
	Surface	35.90	26.5	6	14	11	8	7,967
28	Mid-depth	36.21	22.5	8	2	7	0	11,850
	Bottom	36.24	22.5	6	3	6	0	10,967
	Surface	35.83	28.0	5	12	9	7	6,600
29	Mid-depth	36.04	26.0	4	11	6	10	5,983
	Bottom	36.19	23.0	6	4	8	2	6,985
	Surface	36.11	29.0	2	5	7	4	5,417
30	Mid-depth	36.11	28.5	5	3	5	3	5,584
	Bottom	36.35	24.5	4	2	4	0	5,983
	Surface	35.71	30.5	3	6	7	3	5,567
31	Mid-depth	35.83	29.5	3	1	4	0	5,600
	Bottom	36.40	25.0	5	2	5	0	984
	Surface	35.66	27.5	1	2	3	2	150
32	Mid-depth	35.63	27.5	1	1	2	1	100
	Bottom	36.14	25.5	1	3	4	2	200

STATION N

Cruise No.	Sample Depth	Salinity o/oo	Temp. °C	Un-armored	Armored	Total Genera	Filtered	Total Count
	Surface	35.87	25.5	9	5	10	5	3,433
33	Mid-depth	35.68	25.5	3	1	3	3	317
	Bottom	35.83	25.0	4	3	5	3	350
	Surface	36.16	22.5	4	14	11	15	5,967
34	Mid-depth	36.07	22.5	3	15	8	11	6,800
	Bottom	36.09	22.0	2	5	5	3	5,417
	Surface	36.30	20.5	4	11	9	9	8,217
35	Mid-depth	36.18	20.0	5	5	8	6	5,683
	Bottom	36.19	19.8	6	8	8	8	3,550
	Surface	36.19	18.5	8	13	12	9	7,017
36	Mid-depth	36.19	18.5	6	9	9	7	6,834
	Bottom	36.19	18.5	5	7	8	7	6,284
	Surface	36.28	19.0	4	14	11	9	3,967
37	Mid-depth	36.16	18.5	1	5	2	5	300
	Bottom	36.28	18.0	5	3	4	3	3,367
	Surface	36.31	21.5	5	14	10	12	8,083
38	Mid-depth	36.38	21.0	1	5	4	5	5,250
	Bottom	36.24	20.0	4	3	5	1	5,300
	Surface	36.36	25.5	2	10	7	9	1,950
39	Mid-depth	36.18	24.0	3	8	8	8	1,000
	Bottom	36.08	22.0	3	4	6	3	1,033
	Surface	36.40	26.5	4	10	10	6	8,217
40	Mid-depth	36.45	25.0	5	4	7	5	5,584
	Bottom	36.23	22.0	6	2	7	3	5,750
	Surface	36.35	29.5	2	5	6	5	5,300
41	Mid-depth	36.07	26.0	2	3	4	3	7,650
	Bottom	36.24	20.0	0	3	2	3	150
	Surface	35.23	29.5	3	5	5	4	5,300
42	Mid-depth	36.06	25.0	8	7	10	8	5,767
	Bottom	36.31	20.5	5	4	5	3	5,467
	Surface	35.57	29.0	4	6	8	5	5,350
43	Mid-depth	35.50	28.5	6	10	9	9	11,051
	Bottom	36.49	21.0	3	0	3	0	5,050
	Surface	35.61	26.0	7	10	10	11	205,717
44	Mid-depth	35.57	26.0	4	15	14	14	258,034
	Bottom	36.31	23.0	4	1	4	2	481,100
	Surface	36.22	21.0	11	23	14	29	31,600
45	Mid-depth	36.04	21.5	9	19	14	18	24,101
	Bottom	36.22	21.0	2	2	3	2	10,100

STATION G

Cruise No.	Sample Depth	Salinity o/oo	Temp. °C	Un-armored	Armored	Total Genera	Filtered	Total Count
	Surface	32.22	29.5	2	1	3	1	600
18	Mid-depth	32.22	29.5	3	3	5	1	2,034
	Bottom	36.11	29.8	1	1	2	0	217
	Surface	36.16	30.0	5	5	8	1	6,083
19	Mid-depth	36.21	30.0	4	5	8	1	12,350
	Bottom	36.21	27.8	3	1	3	0	6,883
	Surface	35.87	28.0	7	3	6	0	85,116
20	Mid-depth	33.61	27.5	6	2	6	0	53,700
	Bottom	34.01	26.5	4	2	5	2	53,984
	Surface	35.52	24.0	4	9	7	5	1,617
21	Mid-depth	35.48	23.5	6	6	9	5	1,567
	Bottom	35.47	23.5	6	4	6	4	3,800
	Surface	35.32	21.0	7	6	8	6	7,283
22	Mid-depth	35.32	21.0	3	1	4	1	2,267
	Bottom	35.32	21.0	4	4	5	3	2,034
	Surface	35.34	20.8	4	11	9	1	11,334
23	Mid-depth	35.37	20.1	5	6	10	6	9,684
	Bottom	35.56	20.5	6	8	8	3	7,117
	Surface	35.09	19.0	8	17	11	6	33,385
24	Mid-depth	35.16	16.0	4	11	8	4	6,217
	Bottom	35.19	16.0	3	3	5	1	8,267
	Surface	35.16	19.0	6	11	10	8	55,100
25	Mid-depth	35.21	19.0	6	8	10	5	55,068
	Bottom	35.21	19.5	7	11	10	8	9,001
	Surface	34.92	20.0	10	17	14	15	63,234
26	Mid-depth	35.02	19.5	6	15	8	7	57,850
	Bottom	35.97	19.5	6	8	9	8	52,167
	Surface	35.64	24.5	7	12	11	8	57,983
27	Mid-depth	35.61	24.5	4	5	5	4	6,133
	Bottom	35.51	23.5	7	3	6	3	6,184
	Surface	35.39	26.5	5	5	7	1	5,733
28	Mid-depth	35.39	26.5	5	6	8	2	52,801
	Bottom	35.83	25.5	4	5	6	0	52,750
	Surface	35.50	29.0	8	14	10	7	518,716
29	Mid-depth	35.82	27.5	4	13	13	9	6,250
	Bottom	35.90	28.0	3	10	8	4	5,951
	Surface	36.31	30.5	3	11	9	6	2,717
30	Mid-depth	35.73	30.0	7	10	12	2	1,201
	Bottom	36.02	29.0	2	5	6	3	350
	Surface	35.18	30.5	5	4	6	0	7,967
31	Mid-depth	35.63	30.0	3	1	4	0	7,717
	Bottom	36.14	29.0	3	9	7	4	18,234
	Surface	35.39	28.5	2	2	4	1	200
32	Mid-depth	35.46	28.5	3	1	4	2	317
	Bottom	35.52	28.5	1	3	3	2	5,150

STATION G

Cruise No.	Sample Depth	Salinity o/oo	Temp. °C	Un-armored	Armored	Total Genera	Filtered	Total Count
	Surface	36.02	25.0	7	5	6	3	60,183
33	Mid-depth	35.97	25.0	7	5	7	4	56,134
	Bottom	36.00	25.0	5	0	4	1	54,267
	Surface	35.25	22.0	8	3	7	4	10,016
34	Mid-depth	35.27	21.5	8	1	6	2	8,701
	Bottom	35.23	21.0	5	3	6	2	8,700
	Surface	36.12	20.0	8	5	8	1	8,217
35	Mid-depth	36.16	20.0	2	7	5	6	5,517
	Bottom	36.09	20.0	1	10	4	10	833
	Surface	35.52	18.5	9	14	13	11	7,684
36	Mid-depth	35.61	18.5	2	13	10	13	3,200
	Bottom	35.85	18.0	6	14	9	13	7,799
	Surface	37.73	18.0	10	21	15	14	7,252
37	Mid-depth	35.76	17.5	3	8	7	5	6,400
	Bottom	35.78	17.5	5	9	8	3	3,884
	Surface	35.78	21.5	6	17	13	8	7,851
38	Mid-depth	35.82	21.0	11	12	13	8	7,184
	Bottom	35.95	21.0	2	2	4	1	5,150
	Surface	36.14	26.5	6	14	13	9	6,134
39	Mid-depth	36.11	25.5	6	6	8	5	1,950
	Bottom	36.14	25.5	5	6	7	4	1,517
	Surface	36.33	27.5	2	0	2	0	1,166
40	Mid-depth	36.26	27.0	5	0	3	1	5,550
	Bottom	36.26	24.5	2	5	6	4	10,367
	Surface	36.02	30.0	8	23	12	5	3,485
41	Mid-depth	36.07	30.0	5	7	8	7	3,284
	Bottom	36.23	29.0	3	3	5	3	5,200
	Surface	36.23	30.5	6	11	10	9	10,750
42	Mid-depth	36.28	30.0	4	7	8	4	8,351
	Bottom	36.24	22.5	7	6	8	2	1,735
	Surface	35.48	29.5	6	7	10	6	5,600
43	Mid-depth	35.44	29.5	4	4	6	4	517
	Bottom	36.17	24.5	3	5	7	1	5,534
	Surface	35.70	26.5	7	4	8	6	33,567
44	Mid-depth	35.70	26.5	3	3	5	4	22,700
	Bottom	35.91	26.0	2	2	4	2	10,100
	Surface	35.95	24.5	6	13	10	12	25,316
45	Mid-depth	35.91	24.5	9	12	13	11	10,750
	Bottom	35.93	24.5	6	10	10	10	25,433

STATION O

Cruise No.	Sample Depth	Salinity o/oo	Temp. °C	Un-armored	Armored	Total Genera	Filtered	Total Count
	Surface	35.35	29.3	7	7	9	2	54,234
18	Mid-depth	33.18	29.3	5	6	8	2	53,800
	Bottom	35.71	29.3	5	6	6	2	52,851
	Surface	35.58	29.9	7	7	10	5	21,633
19	Mid-depth	35.68	29.7	6	8	9	7	6,733
	Bottom	35.46	27.5	6	7	11	3	75,251
	Surface	35.46	26.0	5	3	6	3	2,417
20	Mid-depth	35.59	26.0	5	3	6	2	1,867
	Bottom	35.87	25.0	5	4	7	1	6,250
	Surface	34.68	22.5	7	13	10	11	38,651
21	Mid-depth	34.65	23.0	8	9	11	7	27,400
	Bottom	35.43	23.0	7	14	10	6	25,367
	Surface	35.25	19.8	9	16	14	8	14,651
22	Mid-depth	35.54	19.7	5	12	12	10	7,149
	Bottom	35.63	20.0	5	4	5	2	6,750
	Surface	35.01	18.5	8	13	11	9	9,768
23	Mid-depth	34.39	18.5	8	10	11	6	12,502
	Bottom	35.30	18.5	8	5	10	2	8,234
	Surface	35.18	17.0	6	19	12	12	10,301
24	Mid-depth	35.27	17.0	5	12	11	9	6,835
	Bottom	35.34	17.0	6	4	7	4	6,417
	Surface	34.23	20.0	9	20	14	11	13,218
25	Mid-depth	34.59	18.0	5	14	10	8	8,866
	Bottom	35.56	18.5	8	15	10	12	9,067
	Surface	34.75	20.0	6	12	11	7	12,668
26	Mid-depth	34.85	19.5	6	10	9	4	9,019
	Bottom	35.92	20.0	6	6	8	4	8,918
	Surface	35.37	24.8	9	14	10	7	8,116
27	Mid-depth	35.35	24.5	4	7	9	5	7,134
	Bottom	35.39	25.0	4	4	4	4	5,467
	Surface	35.88	27.5	4	22	8	15	8,601
28	Mid-depth	35.66	26.5	5	5	5	3	6,850
	Bottom	35.78	26.5	3	3	6	1	5,651
	Surface	35.85	28.5	9	16	12	7	61,367
29	Mid-depth	35.63	28.5	8	22	14	10	14,485
	Bottom	35.56	28.0	6	10	9	4	10,100
	Surface	3606	30.0	3	19	15	14	7,184
30	Mid-depth	35.85	30.0	8	15	16	9	7,733
	Bottom	35.82	29.0	8	8	11	2	57,116
	Surface	35.52	30.5	5	4	6	3	14,584
31	Mid-depth	35.54	30.5	2	6	6	5	8,350
	Bottom	35.97	28.5	2	1	3	0	6,217
	Surface	35.34	27.5	3	5	5	4	634
32	Mid-depth	35.42	27.5	5	2	4	2	5,300
	Bottom	35.46	27.5	5	2	4	2	5,417

STATION O

Cruise No.	Sample Depth	Salinity o/oo	Temp. °C	Un-armored	Armored	Total Genera	Filtered	Total Count
	Surface	35.85	24.5	8	5	7	4	3,233
33	Mid-depth	35.83	24.5	3	4	6	4	1,700
	Bottom	35.82	24.0	7	5	7	7	884
	Surface	35.39	20.5	7	2	5	1	10.367
34	Mid-depth	35.39	20.5	8	3	6	2	11,850
	Bottom	35.39	20.0	7	2	4	0	8,967
	Surface	35.32	18.8	5	12	10	11	8.034
35	Mid-depth	35.50	18.8	4	9	8	7	6,234
	Bottom	35.47	19.0	4	7	9	6	5.900
	Surface	35.61	18.5	12	19	15	10	10,183
36	Mid-depth	35.63	17.5	5	15	11	15	7,583
	Bottom	35.74	17.5	6	13	11	12	8,701
	Surface	35.40	18.5	6	15	11	12	8,918
37	Mid-depth	35.35	18.0	5	14	11	4	8,934
	Bottom	35.54	17.5	5	11	9	4	5,334
	Surface	35.34	28.0	7	20	14	14	7,934
38	Mid-depth	35.35	21.5	4	13	11	9	7,651
	Bottom	35.95	20.5	6	10	12	4	6,317
	Surface	35.92	25.5	4	8	10	6	1,450
39	Mid-depth	35.85	25.5	6	4	7	3	40,917
	Bottom	35.97	25.0	3	5	5	3	19,700
	Surface	36.19	27.5	4	13	10	9	8,718
40	Mid-depth	36.21	25.5	3	7	7	6	7,900
	Bottom	36.19	24.5	6	12	9	9	10,083
	Surface	36.28	30.0	11	19	13	10	12,534
41	Mid-depth	36.30	30.0	7	16	10	10	11,518
	Bottom	36.28	28.0	7	12	9	6	12,433
	Surface	36.07	30.0	8	22	14	10	15,268
42	Mid-depth	36.16	30.0	8	12	10	3	14,052
	Bottom	36.11	30.0	5	14	9	8	6,467
	Surface	35.50	29.0	7	11	8	10	56,317
43	Mid-depth	35.50	29.0	8	7	9	9	45,434
	Bottom	35.22	25.0	5	13	11	13	47,484
	Surface	35.62	25.5	11	17	13	12	84,550
44	Mid-depth	35.64	25.5	10	18	16	10	54,717
	Bottom	35.68	25.5	11	11	10	4	73,534
	Surface	35.82	21.0	6	4	6	4	10,517
45	Mid-depth	35.81	21.0	7	6	8	6	10,617
	Bottom	35.84	21.0	5	3	6	4	7,800

STATION H

Cruise No.	Sample Depth	Salinity o/oo	Temp. °C	Un-armored	Armored	Total Genera	Filtered	Total Count
	Surface	31.46	36.5	5	10	10	6	13,001
18	Mid-depth	31.10	30.5	4	4	7	0	7,816
	Bottom	38.68	30.0	3	2	5	1	53,550
	Surface	32.72	31.2	5	16	12	5	22,952
19	Mid-depth	35.51	31.0	5	8	8	3	52,950
	Bottom	36.02	30.7	3	3	6	9	55,317
	Surface	34.51	29.0	4	10	10	4	4,401
20	Mid-depth	35.09	29.0	2	5	7	1	3,101
	Bottom	35.25	29.0	3	1	4	0	21,167
	Surface	34.81	23.0	4	0	4	0	38,834
21	Mid-depth	34.87	23.0	5	1	5	1	91,100
	Bottom	35.19	22.0	5	5	10	1	32,917
	Surface	34.83	19.5	10	13	11	5	59,552
22	Mid-depth	34.89	19.5	9	8	11	5	77,234
	Bottom	34.95	19.5	5	3	7	0	66,933
	Surface	33.77	20.5	3	2	3	2	3,606
23	Mid-depth	34.46	20.0	6	9	11	4	6,550
	Bottom	34.70	19.5	4	4	7	0	8,601
	Surface	32.87	15.5	4	4	6	0	11,885
24	Mid-depth	33.23	14.0	3	8	6	3	12,634
	Bottom	33.23	14.0	3	3	5	0	8,200
	Surface	34.03	20.5	6	14	10	3	54,867
25	Mid-depth	34.03	20.5	5	10	10	4	9,235
	Bottom	34.01	20.5	3	15	10	11	51,467
	Surface	34.70	21.5	6	9	7	4	52,051
26	Mid-depth	34.68	21.5	7	12	9	8	62,335
	Bottom	34.90	21.5	5	5	6	4	51,067
	Surface	34.52	26.5	5	10	9	4	58,235
27	Mid-depth	34.77	26.0	6	2	5	3	6,034
	Bottom	35.18	26.5	4	6	6	2	11,651
	Surface	34.23	27.0	8	9	9	3	2,718
28	Mid-depth	34.39	27.0	5	3	6	1	52,200
	Bottom	34.97	27.0	3	7	8	1	56,417
	Surface	33.60	30.0	5	18	9	3	10,150
29	Mid-depth	34.85	29.0	3	18	10	3	3,866
	Bottom	35.25	29.5	3	17	10	2	6,751
	Surface	32.63	31.5	6	19	10	4	11,385
30	Mid-depth	34.11	31.5	6	17	11	1	17,268
	Bottom	34.11	31.5	2	13	9	0	12,733
	Surface	32.91	32.0	2	6	7	1	63,367
31	Mid-depth	34.08	32.0	4	11	8	0	61,450
	Bottom	35.39	31.5	3	4	7	2	7,650
	Surface	34.46	29.0	2	16	9	6	8,217
32	Mid-depth	34.47	29.0	1	8	6	3	1,534
	Bottom	34.34	29.0	1	4	4	2	1,200

STATION H-2

Cruise No.	Sample Depth	Salinity o/oo	Temp. °C	Un-armored	Armored	Total Genera	Filtered	Total Count
33	Surface	33.94	24.0	5	15	9	5	59,817
	Mid-depth	34.13	23.5	2	8	9	4	52,634
	Bottom	34.27	23.5	3	6	6	3	53,817
34	Surface	34.15	19.5	3	3	6	0	6,317
	Mid-depth	34.32	19.0	4	4	7	0	51,534
	Bottom	34.30	18.5	4	1	5	0	7,150
35	Surface	35.06	18.5	5	6	7	0	1,067
	Mid-depth	35.13	18.5	4	5	5	1	6,017
	Bottom	35.06	18.5	2	9	7	1	6,184
36	Surface	35.06	19.0	3	8	7	4	6,466
	Mid-depth	35.13	19.0	4	2	5	0	5,367
	Bottom	35.06	19.0	3	3	6	0	5,367
37	Surface	34.87	20.5	6	14	10	6	6,867
	Mid-depth	34.95	18.5	4	10	9	5	6,784
	Bottom	34.95	19.0	3	6	6	3	7,417
38	Surface	35.56	23.0	5	11	8	6	8,884
	Mid-depth	35.56	22.5	4	3	6	1	6,367
	Bottom	35.56	22.5	4	3	6	1	5,583
39	Surface	36.52	28.5	7	15	13	6	12,868
	Mid-depth	36.52	28.0	6	15	12	4	10,584
	Bottom	36.59	28.0	3	7	7	2	9,683
40	Surface	36.41	30.0	9	17	13	15	39,250
	Mid-depth	36.38	29.0	7	10	10	3	8,118
	Bottom	36.31	29.0	4	11	9	3	6,551
41	Surface	36.38	31.5	7	22	10	1	48,267
	Mid-depth	36.36	31.5	5	27	10	3	43,269
	Bottom	36.50	31.5	3	16	9	0	28,151
42	Surface	35.74	30.5	7	15	10	6	32,083
	Mid-depth	35.93	30.5	5	11	9	8	10,817
	Bottom	35.95	30.5	3	5	6	0	5,317
43	Surface	35.43	30.5	4	16	9	2	12,183
	Mid-depth	35.55	30.5	5	21	10	8	12,734
	Bottom	35.63	30.5	3	8	7	3	5,567
44	Surface	33.15	27.0	2	5	5	4	15,533
	Mid-depth	34.87	26.5	4	3	6	1	22,867
	Bottom	34.97	26.5	4	3	6	3	22,750
45	Surface	33.55	24.5	4	12	8	6	57,735
	Mid-depth	34.81	24.5	3	3	5	1	20,650
	Bottom	34.92	21.5	11	23	15	29	31,600

STATION P

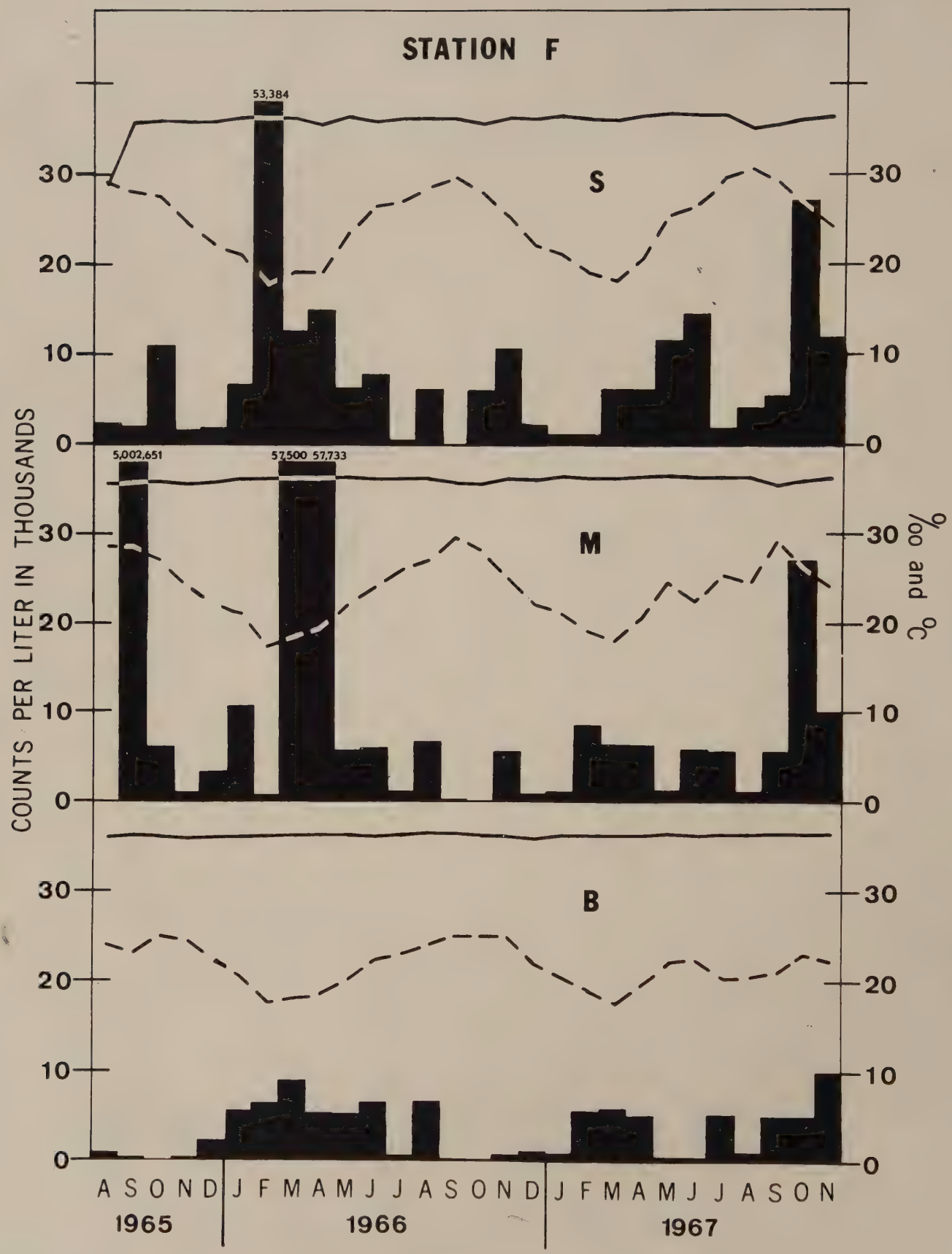
Cruise No.	Sample Depth	Salinity o/oo	Temp. °C	Un-armored	Armored	Total Genera	Filtered	Total Count
	Surface	34.80	32.0	7	20	12	5	57,636
18	Mid-depth	35.09	29.8	3	15	9	5	8,034
	Bottom	34.80	29.8	2	22	9	6	9,251
	Surface	34.68	30.4	5	15	9	7	8,168
19	Mid-depth	24.44	30.3	7	14	13	6	5,552
	Bottom	27.64	30.2	7	3	6	0	6,985
	Surface	34.03	26.0	4	7	7	0	1,918
20	Mid-depth	34.01	26.0	5	7	9	0	21,418
	Bottom	33.96	25.5	3	11	8	1	12,067
	Surface	33.14	23.0	9	6	10	3	50,950
21	Mid-depth	33.11	23.0	7	5	8	2	105,917
	Bottom	33.06	22.5	5	5	7	2	35,300
	Surface	33.05	18.2	5	6	7	1	9,701
22	Mid-depth	33.20	18.2	5	6	7	0	17,017
	Bottom	33.79	18.4	2	6	4	0	6,201
	Surface	34.03	18.5	8	11	9	4	62,118
23	Mid-depth	34.03	18.5	10	10	10	3	58,701
	Bottom	34.03	18.5	5	16	9	8	10,634
	Surface	32.82	18.0	3	21	10	10	2,334
24	Mid-depth	32.63	17.5	2	10	8	2	11,350
	Bottom	32.87	17.0	4	7	7	0	101,967
	Surface	33.41	20.0	5	11	10	3	12,234
25	Mid-depth	33.70	19.5	4	11	8	3	10,451
	Bottom	33.94	19.5	5	7	8	4	5,550
	Surface	34.85	21.5	8	17	11	5	55,585
26	Mid-depth	34.83	20.5	9	12	10	4	52,669
	Bottom	34.87	21.5	7	13	8	2	2,202
	Surface	34.97	26.0	11	24	16	7	73,168
27	Mid-depth	34.92	26.0	12	13	13	8	11,185
	Bottom	34.95	26.0	5	1	5	0	7,434
	Surface	34.94	29.5	5	18	11	6	23,317
28	Mid-depth	35.32	27.5	3	15	9	0	56,717
	Bottom	35.19	27.5	3	6	7	0	60,817
	Surface	34.97	29.0	9	19	13	2	17,834
29	Mid-depth	34.94	29.0	7	22	15	2	15,568
	Bottom	35.35	28.0	4	6	8	2	14,585
	Surface	35.47	31.0	2	12	9	4	51,635
30	Mid-depth	35.39	31.0	1	10	7	1	51,917
	Bottom	35.46	31.0	2	12	10	1	51,352
	Surface	33.94	31.0	5	24	12	3	10,253
31	Mid-depth	33.97	31.0	5	14	10	0	3,601
	Bottom	34.22	31.5	2	3	4	1	10,766
	Surface	34.44	27.5	10	22	14	4	14,268
32	Mid-depth	34.49	27.5	9	16	9	3	10,568
	Bottom	34.51	27.5	5	17	9	1	9,018

STATION P

Cruise No.	Sample Depth	Salinity o/oo	Temp. °C	Un-armored	Armored	Total Genera	Filtered	Total Count
33	Surface	33.99	23.0	6	9	9	3	2,951
	Mid-depth	34.01	22.5	5	10	8	6	10,650
	Bottom	34.78	23.0	4	4	7	2	10,583
34	Surface	33.49	19.0	5	4	7	0	10,200
	Mid-depth	33.39	19.0	4	3	6	0	8,250
	Bottom	33.48	18.5	4	2	6	1	10,317
35	Surface	33.58	19.0	4	13	8	7	11,884
	Mid-depth	33.58	18.4	4	11	8	5	4,100
	Bottom	33.73	19.0	4	10	7	2	7,500
36	Surface	34.30	17.5	6	10	9	2	7,217
	Mid-depth	34.59	18.5	5	11	7	9	6,601
	Bottom	34.71	18.0	4	3	4	2	6,367
37	Surface	34.01	20.0	3	9	9	1	11,250
	Mid-depth	34.13	19.5	5	13	10	4	12,051
	Bottom	34.49	18.5	4	7	8	3	3,351
38	Surface	34.94	22.5	8	11	10	8	11,366
	Mid-depth	35.02	22.5	5	6	7	4	7,900
	Bottom	35.07	22.5	4	6	7	0	6,567
39	Surface	35.82	27.5	5	6	8	3	11,900
	Mid-depth	35.76	27.5	3	4	7	1	9,650
	Bottom	35.80	27.5	3	3	6	1	8,434
40	Surface	36.04	28.5	4	14	10	4	13,983
	Mid-depth	35.95	28.0	3	9	7	3	33,000
	Bottom	35.97	27.5	4	11	9	6	23,150
41	Surface	36.16	30.5	5	11	11	1	42,333
	Mid-depth	36.18	30.5	6	17	11	6	42,700
	Bottom	36.12	30.5	6	14	12	4	21,467
42	Surface	36.00	30.5	6	15	9	3	43,668
	Mid-depth	35.95	30.5	5	2	5	0	12,750
	Bottom	36.04	30.5	3	5	7	1	31,167
43	Surface	34.60	29.5	6	16	10	8	42,701
	Mid-depth	35.01	29.5	6	11	9	5	21,599
	Bottom	35.01	29.5	4	6	7	1	20,967
44	Surface	34.88	25.0	3	16	9	9	14,218
	Mid-depth	34.90	25.0	3	5	6	4	5,417
	Bottom	34.96	25.0	3	9	9	2	11,066
45	Surface	34.20	19.0	8	15	11	9	34,700
	Mid-depth	34.20	19.0	6	11	9	8	11,317
	Bottom	34.13	19.0	6	11	8	10	10,867

APPENDIX VI

Stations F and N (offshore), G and O (middle), and H and P (inshore) were plotted for total dinoflagellate abundance (solid bars) and the corresponding monthly salinities (solid lines) and temperatures (broken lines) from August 1965 (HC Cruise 18) to November 1967 (HC Cruise 45).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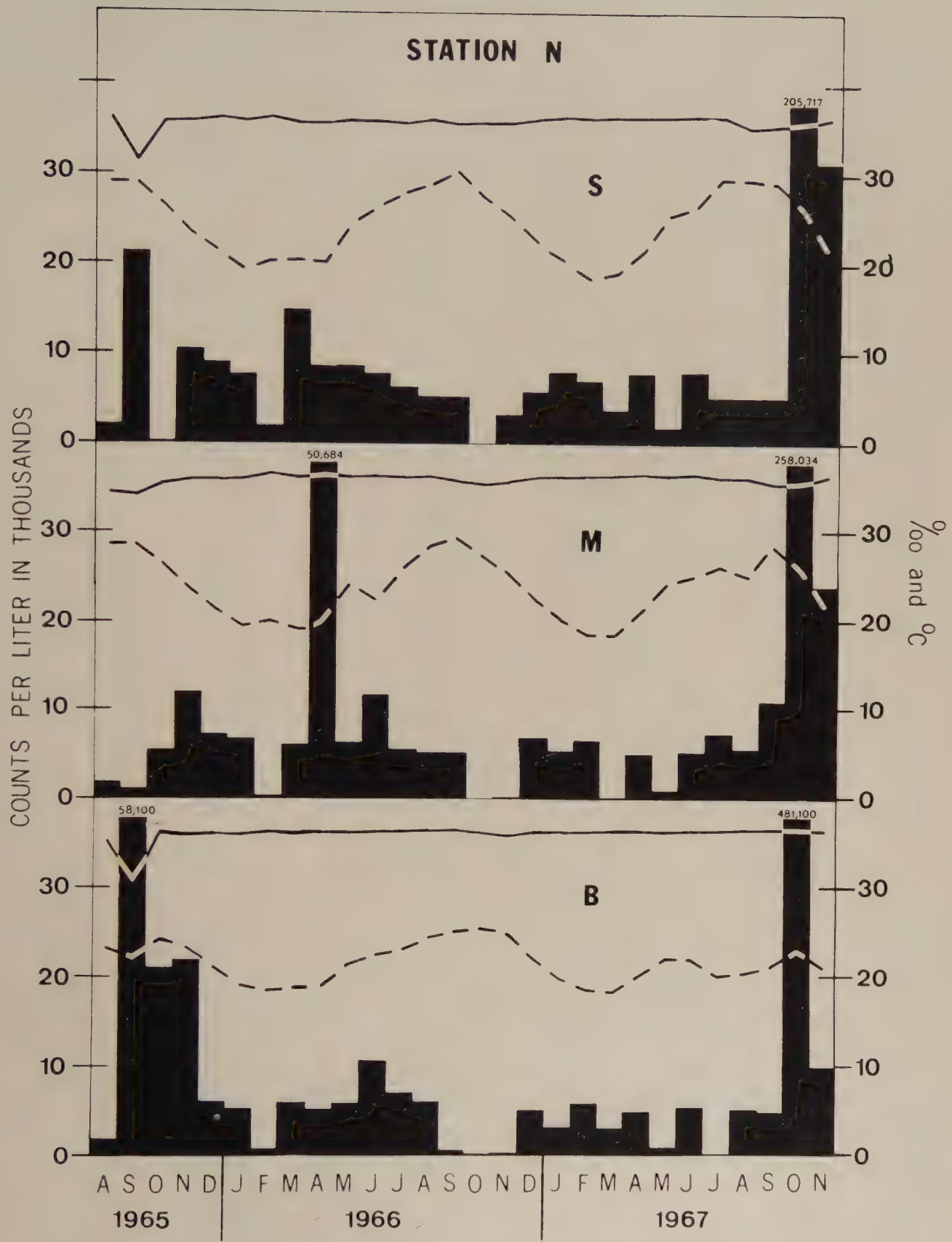
57,500 57,733
S
M
B
30
20
10
0
COUNTS PER LITER IN THOUSANDS
‰ and °C
A S O N D J F M A M J J A S O N D J F M A M J J A S O N
1965
1966
1967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M
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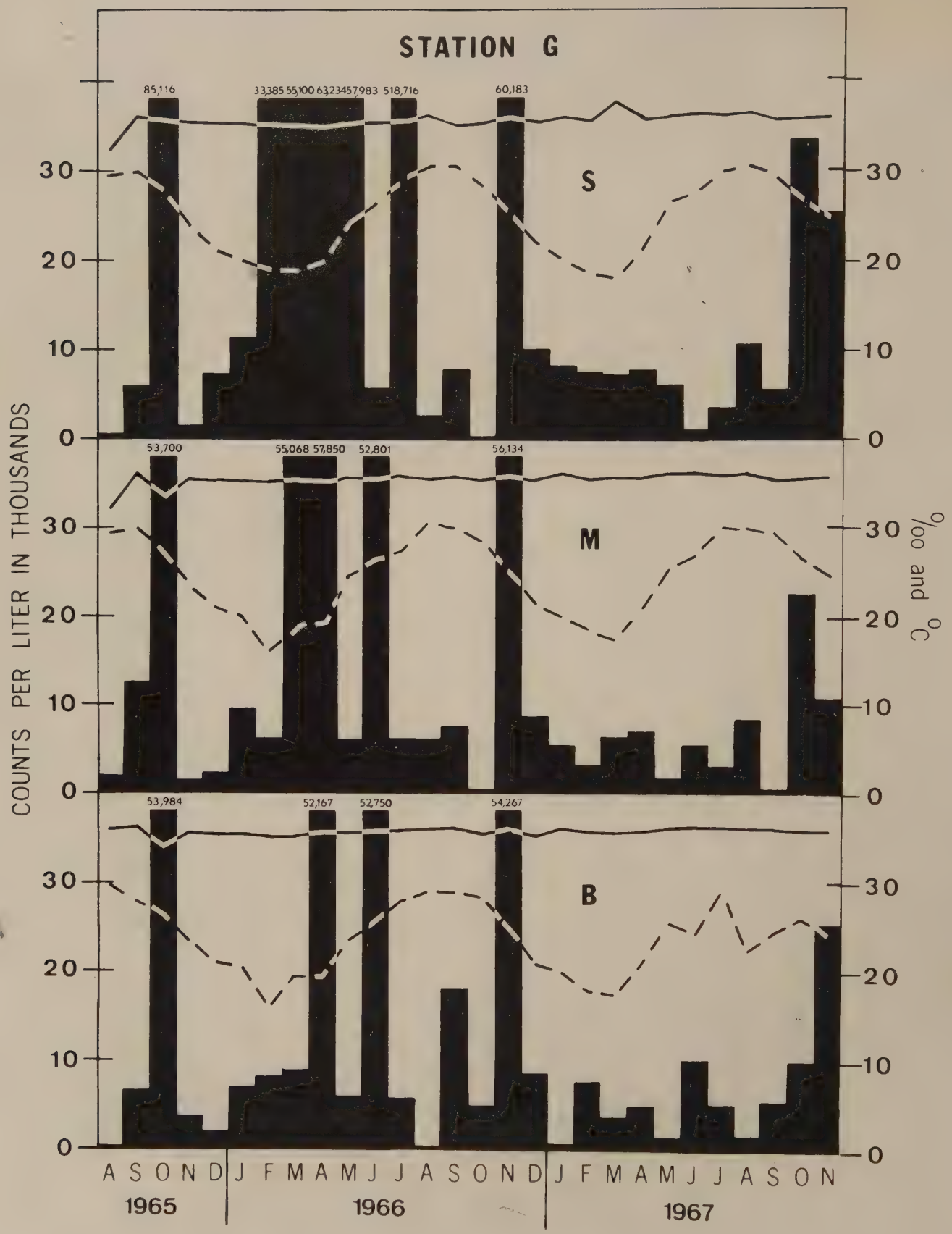
B
30
20
10
0
COUNTS PER LITER IN THOUSANDS
‰ and °C
A S O N D J F M A M J J A S O N D J F M A M J J A S O N
1965
1966
1967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S
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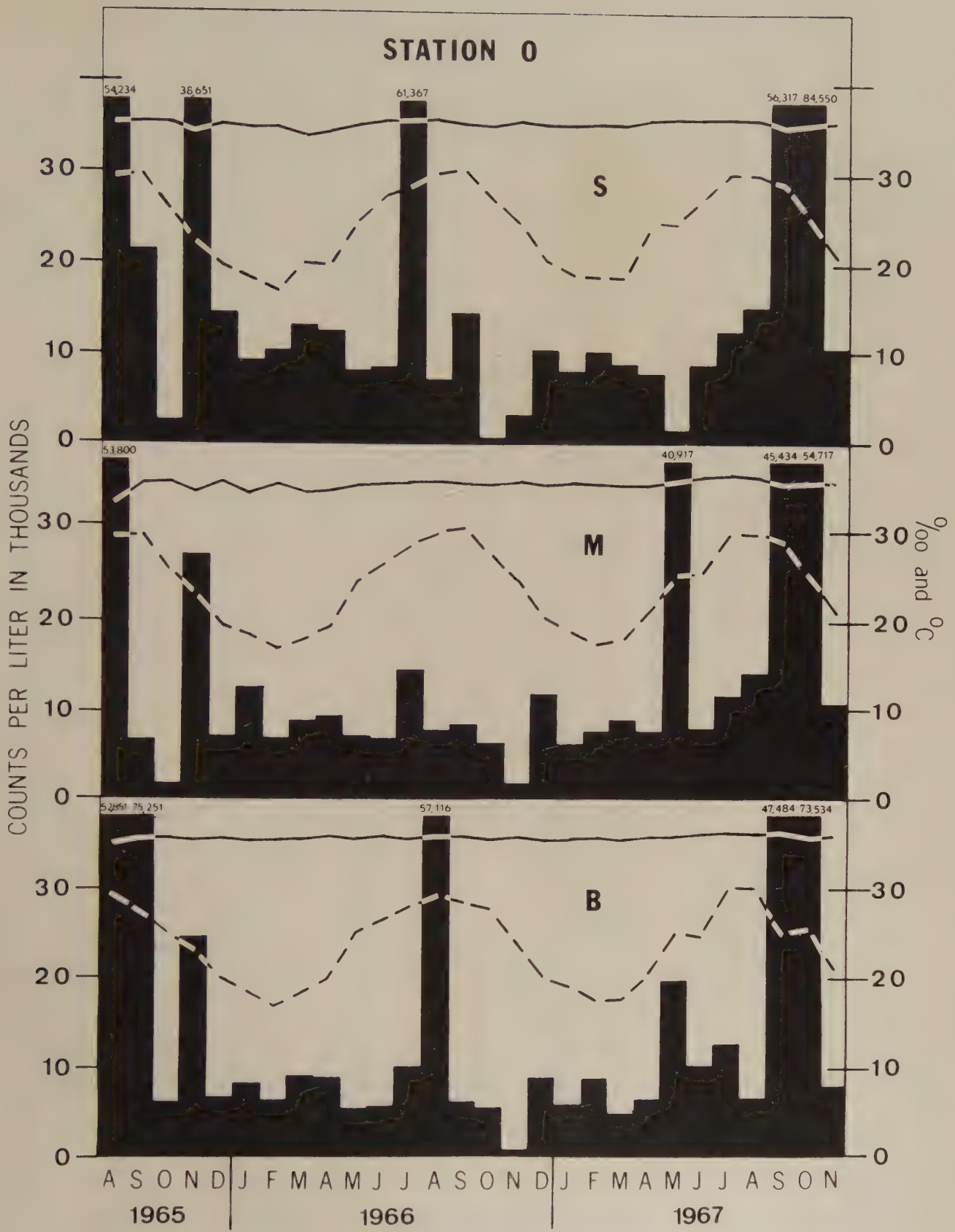
57,850
52,801
56,134
M
53,984
52,167
52,750
54,267
B
30
20
10
0
COUNTS PER LITER IN THOUSANDS
‰ and °C
A S O N D J F M A M J J A S O N D J F M A M J J A S O N
1965
1966
1967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84,550
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45,434
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M
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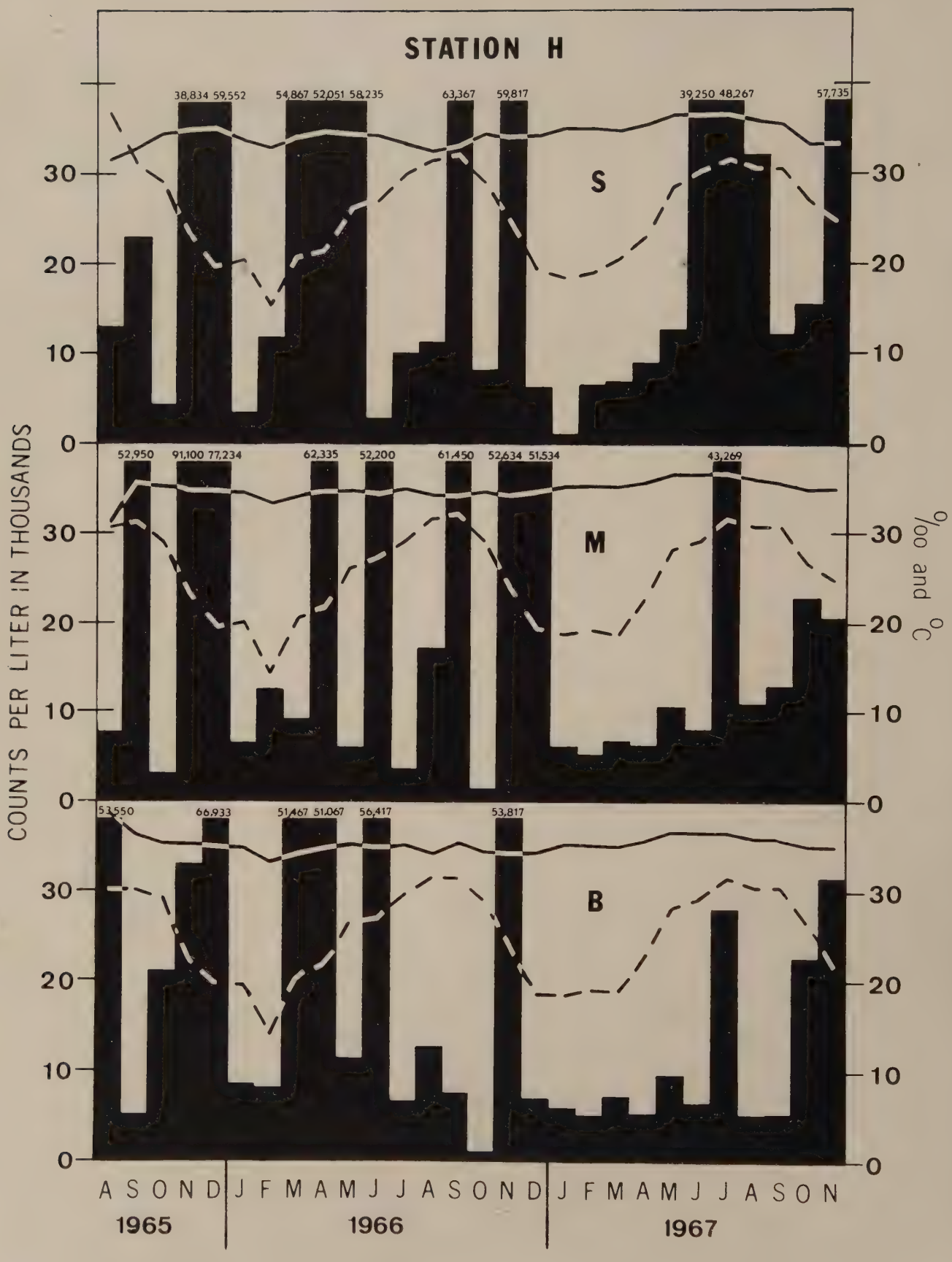
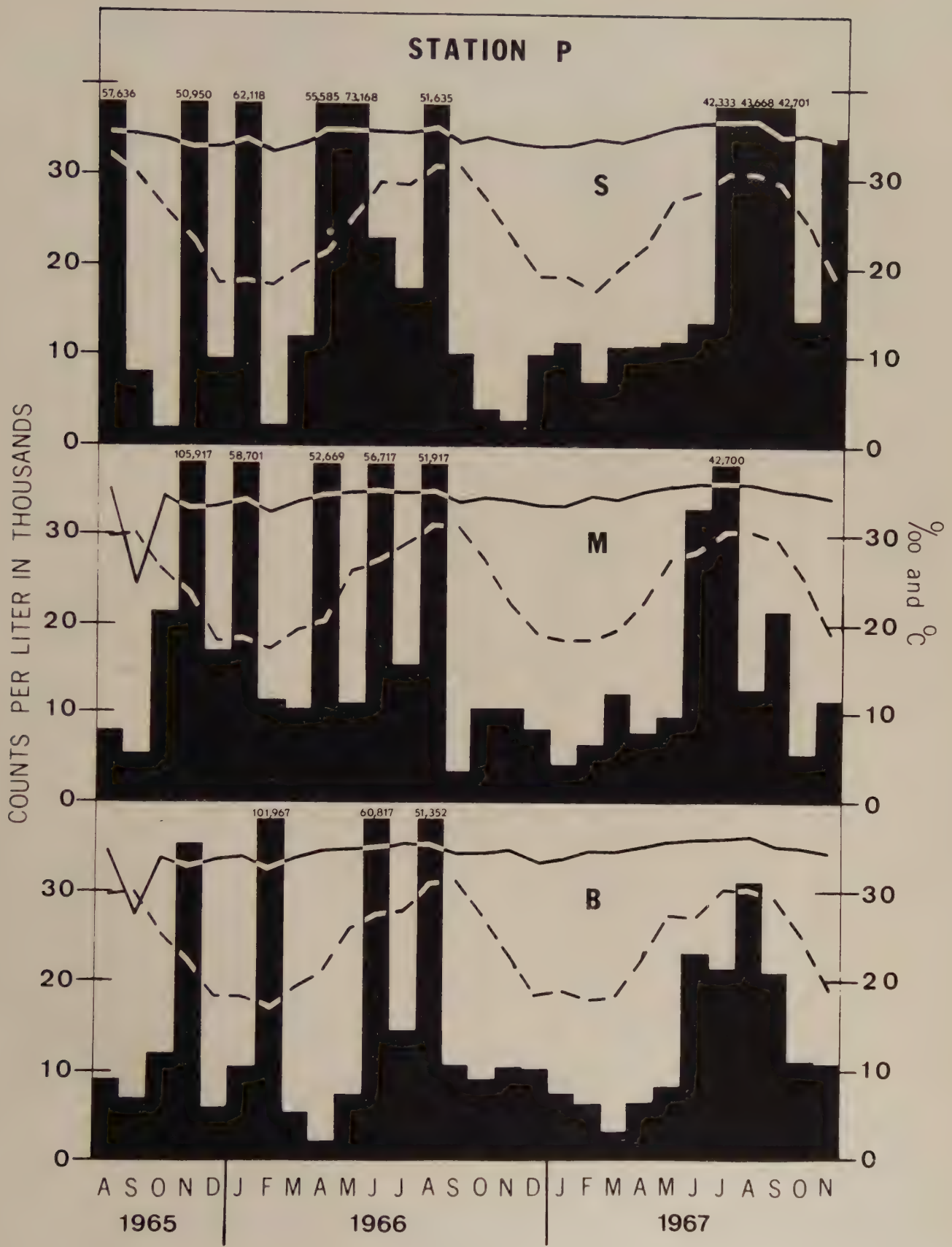
73,534
B
30
20
10
0
COUNTS PER LITER IN THOUSANDS
‰ and °C
A S O N D J F M A M J J A S O N D J F M A M J J A S O N
1965
1966
1967


STATION H
38,834 59,552
54,867 52,051 58,235
63,367
59,817
39,250 48,267
57,735
S
52,950
91,100 77,234
62,335
52,200
61,450
52,634 51,534
43,269
M
53,550
66,933
51,467 51,067
56,417
53,817
B
COUNTS PER LITER IN THOUSANDS
‰ and °C
0
10
20
30
A S O N D J F M A M J J A S O N D J F M A M J J A S O N
1965
1966
1967


STATION P
57,636
50,950
62,118
55,585
73,168
51,635
42,333
43,668
42,701
S
105,917
58,701
52,669
56,717
51,917
42,700
M
101,967
60,817
51,352
B
30
20
10
0
COUNTS PER LITER IN THOUSANDS
‰ and °C
A S O N D J F M A M J J A S O N D J F M A M J J A S O N
1965
1966
1967

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